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ELECTRICAL CONNECTIONS**

**COMPLETION REPORTS FOR SUBTASKS d, e, f, and g**

**CONTRACT NAS 8-11475**

**PREPARED FOR  
GEORGE C. MARSHALL SPACE FLIGHT CENTER  
HUNTSVILLE, ALABAMA**

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# INTEGRITY OF ELECTRICAL CONNECTIONS

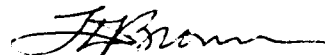
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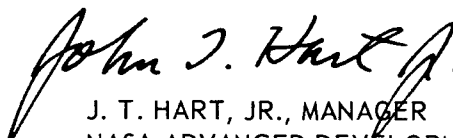
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## FOREWORD

This report presents the results obtained by Lockheed Missiles and Space Company in its investigation of the remaining four (4) subtasks of NASA Marshall Space Flight Center, Contract NAS 8-11475 - Integrity of Electrical Connections.

The results of the first three subtasks of this contract were reported in a four-section report, "Integrity of Electrical Connections Completion Reports for Subtasks (a), (b), and (c), number IMSC/A731415," dated 15 February 1965.

To avoid misleading duplication of numbers, the first section of this report continues with the number five (5).

IMSC-NASA Advanced Development Organization (D/64-50) was responsible for Program Management.

The work was performed by the Process Development Group of Communications and Command (D/55-42) under the direction of Dr. Hans M. Wagner and Dale R. Torgeson.

The Material and Process Control Laboratory (D/48-50) provided testing, evaluation, and photo-micrographic documentation services.

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## SECTION 5

## SUBTASK (d)

## 5.0 PROTECTIVE PACKAGING FOR ELECTRONIC COMPONENTS

5.1 Objective

The objective for Subtask (d) was to develop information on the behavior of plastic materials which are presently used to make storage bags or storage containers for solder-coated, printed circuit boards, or component parts with solder-coated leads. Practical experience has shown that some circuitry and parts being so stored for an extended period of time are contaminated while others remain unchanged.

5.2 Possible Test Methods

The following test values of a storage room would be held constant:

- temperature
- barometric pressure
- relative humidity
- solder composition
- time lapse between solder coating and sealing of parts

Test results would depend only upon the material of the bags and containers used. Two different test configurations can be devised for this subtask.

5.2.1 Solder-coated printed circuit boards and solder-coated component part leads could be enclosed in conventionally sealed plastic bags or plastic containers of the material to be tested and then stored for extended periods of time (1, 2, 4, and 8 months), controlling temperature, barometric pressure, and relative humidity of the storage room. The solderability would be determined after completion of storage time.

5.2.2 The plastic material to be tested, preferably in the form of thin sheets, could be suspended in a hermetically sealed bell jar, through which a stream of dry air or nitrogen is passed at a monitored amount per hour. The atmosphere in the bell jar should be both pressure and temperature controlled. After leaving the bell jar, the gas stream could be passed through a liquid nitrogen trap, in which all substances emanating from the plastic under test are retained for future analysis. Such analysis can be performed by microchemical methods, by chromatography, or possibly by infrared absorption (in solution).

It should be noted that neither of the above two tests procedures should be accelerated by use of elevated temperatures. The behavior of plastic materials is quite temperature dependent and many plastics, which are stable at ambient temperatures, break down, depolymerize, or disintegrate at elevated temperatures.

### 5.3 Test Specimen Materials

At present, a multitude of transparent plastic packaging materials are used in the forms of bags, sheets, and molded containers to protect electronic component parts and circuitry for both long and short term storage. Since it would be impossible to investigate the behavior and protective capability of all the products used presently, IMSC requested that MSFC specify which of the many packaging materials they wished to have investigated.

Unfortunately, this information, which was requested since the beginning of the contractual period, has never been received. It was, therefore, impossible to conduct actual tests under this subtask.

#### 5.4 Recommendations

The following recommendations are based not only upon LMSC's knowledge and experience in the field of plastic packaging materials but also upon consultations with representatives of leading plastics firms such as DuPont and Crown Zellerbach.

- Non-brittle materials should be used to avoid cracks in storage bags.
- Non-porous materials (good vapor barriers) should be used in order to avoid "breathing-in" moisture or other contaminating gases.
- Only materials which do not carry contaminants to the inside of the bag by solid solubility or similar mechanisms should be used.
- The integrity of any plastic container will be no better than the effectiveness of its method of sealing. Therefore, care must always be taken to assure that vapor-tight seals are created.
- To avoid deposition of films on package contents, materials with low plasticizer content should be used to avoid possible out-gassing of deteriorating chemicals, i.e., tricresylphosphate. Plastics in the following general categories all use plasticizers:
  - Vinyl
  - Butyrates
  - Acetates

- Recommended plastic materials for packaging include, but are not limited to the following:
  - Polyethylene
  - Polystyrene (without plasticizer for rigid container applications)
  - Mylar
- Polyethylene packaging containers are particularly recommended because of their chemical inertness. Unfortunately, Polyethylene is a relatively poor vapor barrier. However, by forming a laminate composite with Mylar, which is an excellent vapor barrier, the capability of this material for use as storage containers can be considerably improved. Composites of Polyethylene and Mylar in laminate form combine the best features of both materials. That is, they are transparent, inert, do not outgas, and when properly sealed, prevent moisture contamination.

## Section 6

## SUMMARY

## SUBTASK (e) - INSULATION CLEARANCE

- Purpose. The problem of clearance between a solder connection and insulation requires definition and solution. Existing guide lines are defined in para. 5.2.3 of NASA Quality Publication NPC 200-4. Optimum clearance requirements are to be determined for use as a standard with universal application.

- Results - Recommendations

- Insulation clearances per NPC 200-4 were used throughout all subtask investigations for soldering wires to connector pins and turret terminals. The primary factor in judging insulation clearance was the provision for heat sink attachment. The determination of "Optimum" insulation clearance is closely related to the design of a heat sink with "optimum" qualities. However, this task was not part of subject contract. The insulation clearance specified in NPC 200-4 is designed in consideration of presently used heat sinks. Tests at IMSC have shown that this insulation clearance is "adequate" for fabrication of high quality joints. This adequacy of insulation removal is based upon the fact that no wicking was encountered and no evidence of excessive heat drain was observed for the heat sink sizes, and ranges of wire and terminal attachments studied. A study of the effect of changing the insulation clearance to a fraction or a multiple of its presently specified amount would have required a much more detailed investigation, for which funding was not available.

- For different wire and terminal sizes, and/or masses other than those studied under this contract, an investigation of the specific heat sink design requirements to prevent wicking is recommended. Additional strip gap requirements must be an integral part of this design investigation.

Section 6  
SUBTASK (e)

6.0 INSULATION CLEARANCE

6.1 Objective

To investigate the problem of insulation clearance of "strip gap" and to determine optimum clearance for general recommendation as a standard.

6.2 Test Description

The "strip gap" used in all soldering operations performed under this contract conformed to existing standards as detailed in para. 5.2.3 of NASA Quality Publication NPC 200-4. This clearance was found to be adequate for accommodating the "Little Joe" brand heat sink. Use of this heat sink completely prevented wicking in the stranded wires of these contract investigations. A study program set up to determine optimum clearance would require exploration of heat sink variables of heat conductivity, specific heat of sink, etc., in connection with widely different wire and component sizes and masses. This was beyond the scope of this contract, and therefore not performed.

## SUMMARY

## SUBTASK (f) - INVESTIGATION OF WICKING

● Purpose. To investigate the possibility of damage which could occur when molten solder wicks under cable insulation, and to establish a limit for wicking above or below insulation if test results show this to be a harmless condition. In the event that wicking is determined to be detrimental to joint quality, recommendations are to be submitted for the restriction of wicking to safe limits.

● Results - Recommendations. Wicking was found to reduce the fatigue resistance of stranded cable. This reduction of fatigue resistance also depends upon the plating material of the individual strands. Wicking can be arrested completely by use of adequate clip-on heat sinks. The depth of wicking in stranded cables:

- increases as solder bath temperature increases.
- increases as the immersion time in the solder bath is increased.
- approaches asymptotically a maximum with immersion time.
- is dependent upon the juxtaposition of the wire strands and can therefore be influenced by the insulation stripping procedure.

Test results have been analyzed and it is recommended that:

- (1) soldering time be restricted to five (5) seconds maximum;
- (2) no solder joint be made without the use of a properly dimensioned heat sink;
- (3) no cable with silver-plated strands be used.

SECTION 7  
SUBTASK (f)

7.0 INVESTIGATION OF WICKING

7.1 Objective

The objectives for Subtask (f) were to determine the effects of wicking in stranded wire and the extent to which wicking is affected by process variables. Process variables considered in this investigation were:

- Solder temperature
- Time duration of lead contact with liquid solder
- Use of heat sink
- Heat sink configuration
- Wire size
- Number of strands
- Plating on copper wire

The following parameters were held constant during the entire investigation:

- Wire insulation
- Cleaning method
- Insulation stripping method
- Type of flux
- Type of solder

7.2 Test Description

7.2.1 Basic Test Configurations. Two basic test configurations were selected for these subtask tests. These were:

- Stripped, cleaned, and fluxed stranded wires which were dipped to a precise depth into controlled temperature molten solder.
- Stripped and cleaned stranded wire leads which were hand soldered to connector pins, using flux-cored solder.

A total of 330 specimens were used. These specimens were subdivided into 32 separate test series, each one containing from 7 to 10 individual soldered leads or connections. Test specimen preparation is described in detail in paragraph 7.3.

7.2.2 Stripping of Insulation. Removal of the insulation prior to testing was performed by using a Model 45-174 Mechanical Stripper with blade #L-5563, manufactured by Ideal Industries, Inc., Sycamore, Illinois. The wires were visually checked by the operator to assure that no nicks or cuts had occurred during stripping.

7.2.3 Cleaning of Stripped Wires. The stripped wire ends were cleaned prior to every dip or hand-soldering operation by immersion in chloroethane (1,1,1 - trichloroethane, also known as methylchloroform) and then were thoroughly scrubbed with a bristle brush while immersed.

### 7.3 Test Specimen Preparation

7.3.1 Test Specimen Description. Test specimens were prepared in two different ways:

- Solder-Dipped Stranded Wire Ends.  
Purpose: To determine the amount of wicking which occurs in a clean, insulation-free piece of fluxed stranded wire when dipped to a precisely controlled depth into molten, controlled temperature solder.

Configuration: The ends of insulated stranded wires were stripped for a length of 1/4 inch (except where specified in the Test Series Data Sheets ) from the free end, per paragraph 7.2.2 and then cleaned, per paragraph 7.2.3. The wire ends were next fluxed by dipping them in the liquid flux to a depth of 1/8 inch (See Fig. 7-1). Flux was allowed to dry at room temperature. Each wire end was then dipped to a length of 1/8 inch in a closely controlled temperature solder pot for various lengths of time.

Ref: Test Series Data Sheets No. A1 through A28.

- Stranded Wire Ends Soldered into Cup Terminals.

Purpose: To determine the amount of wicking which occurs in a clean, insulation-free piece of stranded wire when being soldered with and without a heat sink into a connector pin.

Configuration: The ends of insulated stranded wires were stripped as shown in Fig. 7-1 and described in paragraph 7.2.2. They were next cleaned in accordance with paragraph 7.2.3. The wire ends were then soldered into connector pins using the flux and solder specified in paragraph 7.3.2. This operation was performed with and without the heat sinks on the stripped portion of the wire.

Ref: Test Series Data Sheets No. A29, A30, A31, A32.

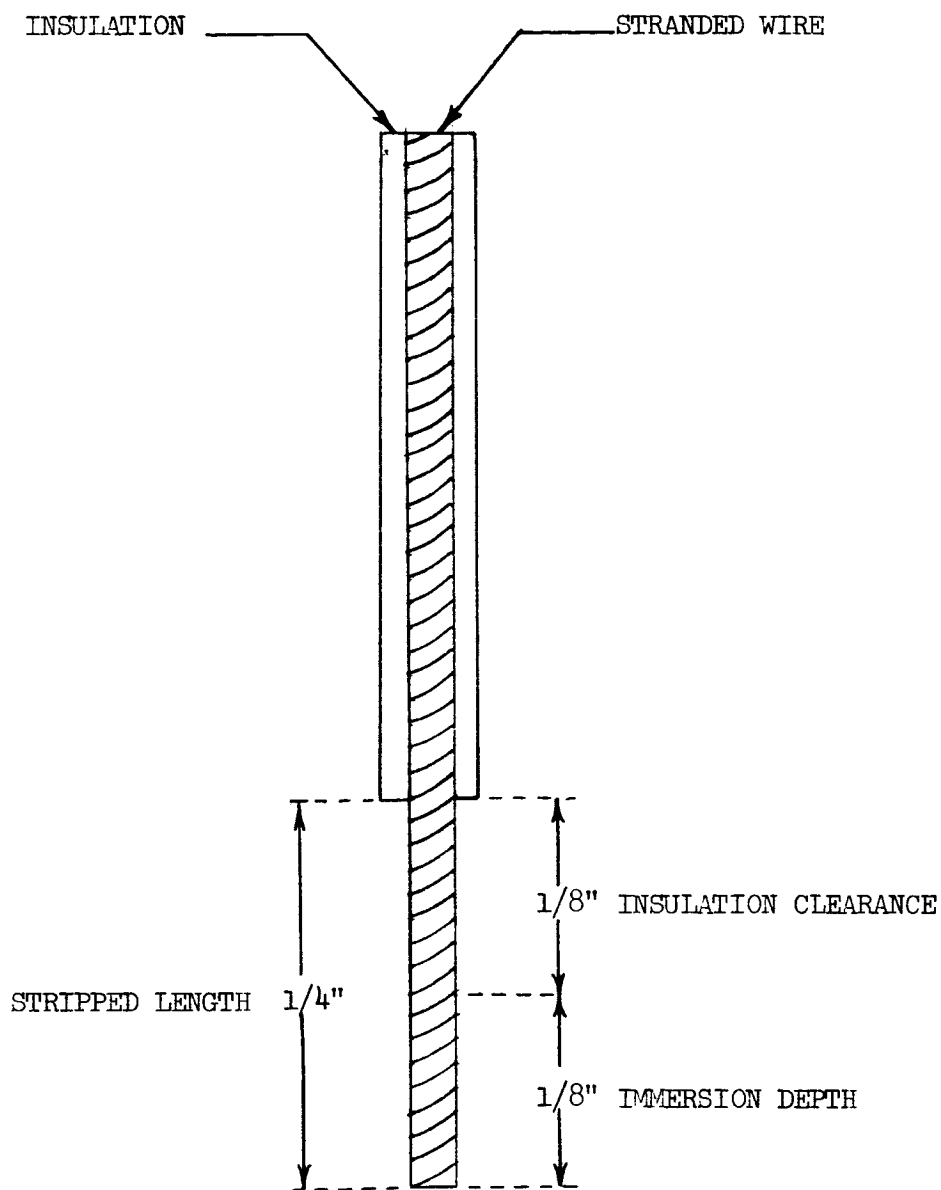
7.3.2 Solder/Flux Combinations. The solder pot immersion tests were performed with Alpha Metals 60/40 molten solder. Fluxing was achieved by dipping wire ends in Alpha Metals # 346-25 liquid flux and drying at room temperature; forced air was not used.

The connector pin tests were performed by using Alpha Metals 60/40 cored solder with N.R.G. (Energized) flux core.

Heat sink used: "Little Joe," manufactured by MacDonald & Co., Glendale, California.

#### 7.4 Materials and Test Equipment

Figure 7-1



TYPICAL STRIPPED STRANDED WIRE

#### 7.4.1 Test Specimen Materials

- The wires used to prepare the test specimens are shown in the following table:

AWG.	NO. OF STRANDS	PLATING METAL	INSULATION
22	19	silver	Teflon
22	19	nickel	Teflon
24	7	nickel	Teflon

For details, see section 9, paragraph 9.1

- The connector pins with solder cup were No. 202, goldplated.  
(See section 8, paragraph 8.4.1)
- The solder/flux combinations that were used are described in paragraph 7.3.2.

#### 7.4.2 Test Equipment and Cleaning Materials

- Fatigue Resistance Testing Machine

See section 9, paragraph 9.3

- Mechanical Cleaning Medium

Bristle brush - LUCO brand, acid-free, no. 1, 3/8 inch.

- Cleaning Solvents.

1,1,1 - trichloroethane

TMC Freon

See section 9, paragraph 9.2

## 7.5 Test Data and Records

This study was directed primarily to measurements of longitudinal solder flow along the test specimen wire strands. Measurements of such flow were made using both macro and micro methods. However, due to the fact that wicking "freezes" the juxtaposition of the strands to one another, thus preventing flexibility in bending, fatigue tests were carried out to determine the amount of strength loss due to wicking.

The measurement of solder flow in the capillaries between wire strands was performed by embedding a suitable length of wire with the insulation on one end and grinding the sample down until a section through the longitudinal axis was obtained. Wicking depth was determined by length measurement and documented by photomicrographs of the sectioned sample.

Fatigue tests were performed using the method and equipment described in section 9, paragraph 9.3, pages 9-5 and 9-6.

Test data are recorded on individual Test Data Sheets, presented in section 9, paragraph 9.4, pages 9-7 through 9-19.

## 7.6 Test Results

### 7.6.1 Depth of Wicking Measurements

The depth of wicking, i.e., the height to which the molten solder rises in the capillary channels between the wire strands was found to increase with temperature of the solder bath and with immersion time. An average of 12 specimens was prepared for each selected test condition; but only one specimen of each test series was longitudinally sectioned for measurement of wicking depth.

Figure 7-2 shows the wicking depth at 450°F as a function of the immersion time. Figure 7-3 presents this information for the solder bath temperature of 550°F. Both diagrams clearly show the trend of increasing wicking depth with time and temperature rise. This dependency becomes even more obvious when averaging the results for each immersion time and temperature; see the "AVG." curves in Figures 7-2 and 7-3.

The relatively large spread of individual measurements around the average curve requires explanation. The amount of wicking for a given temperature and a given immersion time is definitely dependent upon the free diameter of the capillary channels between the wire strands. This free diameter is strongly affected by the stripping of insulation. Whether the insulation is removed by a thermal stripper or by a mechanical stripper (with or without a twisting motion in the direction of the lay of the stranded wire), the juxtaposition of the strands relative to one another changes. This change is sufficient to cause a variation in the depth of wicking.

Tests with a soldering iron (joining of the stranded wire to connector pins) indicated wicking in the same order of magnitude as observed in dipping. These tests also indicated complete absence of wicking when a heat sink was used.

Figure 7-4 shows a longitudinal section through a stranded wire after wicking. It can be seen that the solder has completely filled the capillary channels between the wire strands.

The usefulness of a heat sink for preventing wicking is illustrated in the following photomicrographs.

Figure 7-5 shows a longitudinal section through a specimen from test series A29, a 19 strand, 22AWG, nickel-plated copper wire soldered into the cup of a connector pin. A heat sink had been attached just above the edge of the solder cup. No wicking occurred.

Each Point of the Curves Represents One Measurement:

Curve 1: A5, A6, A7, A8 - Nickel-plated copper wire, Teflon insulation, 22 AWG, 19 strand.

Curve 2: A21, A22, A23, A24 - Silver-plated copper wire, Teflon insulation, 22 AWG, 19 strand.

Curve 3: A25, A26, Nickel-plated copper wire, Teflon insulation, 24 AWG, 7 strand.

All specimens were dip soldered with Alpha Metals 60/40 using Alpha Metals #346-25 liquid flux.

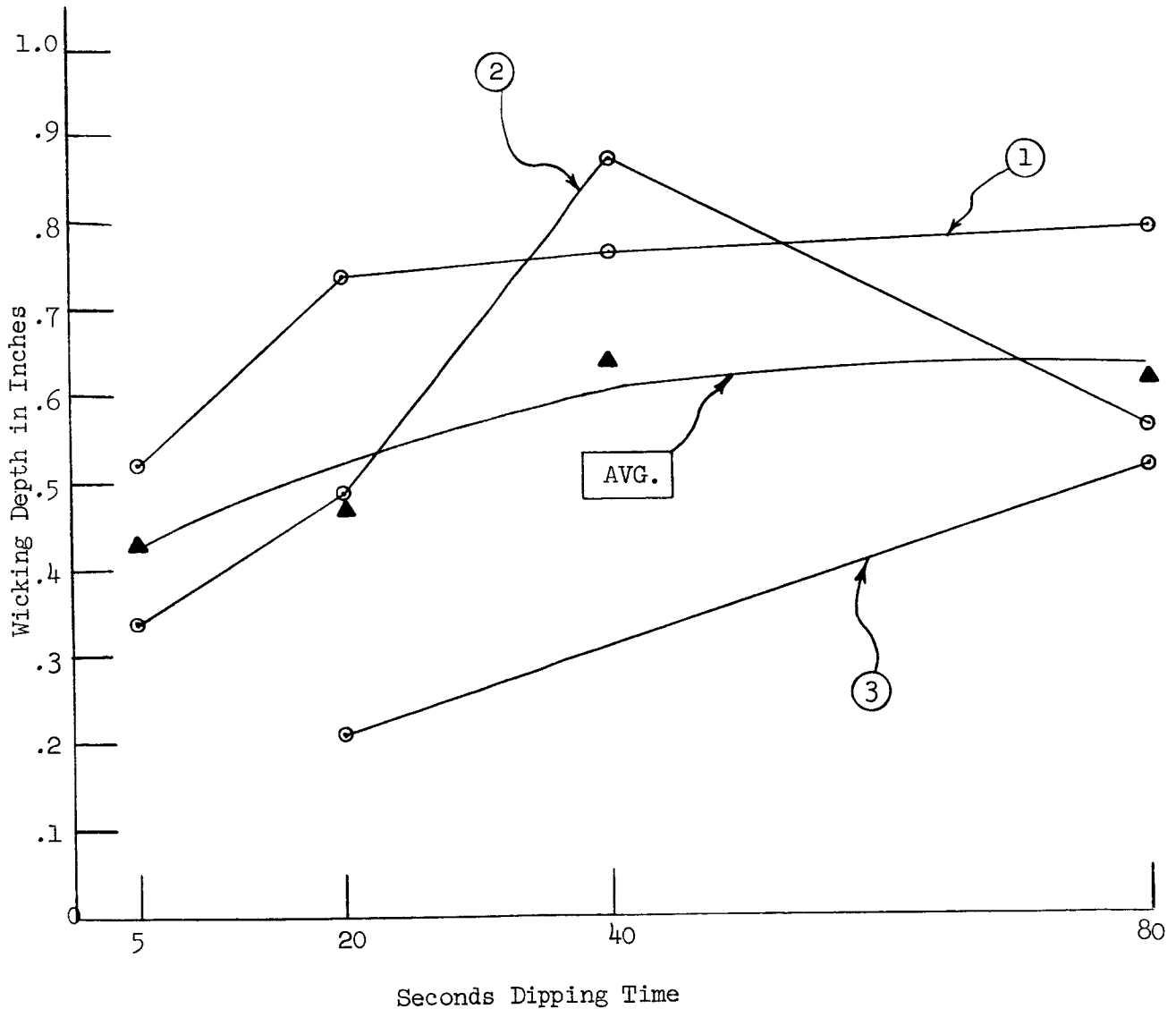


Figure 7-2: Wicking Depth and Immersion Time at 450°F

Each Point of the Curves Represents One Measurement:

Curve 1: A13, A14, A15, A16 - Nickel-plated copper wire, Teflon insulation, 22 AWG, 19 strand.

Curve 2: A17, A18, A19, A20 - Silver-plated copper wire, Teflon insulation, 22 AWG, 19 strand.

Curve 3: A27, A28 - Nickel-plated copper wire, Teflon insulation, 24 AWG, 7 strand.

All specimens were dip soldered with Alpha Metals 60/40 using Alpha Metals #346-25 liquid flux.

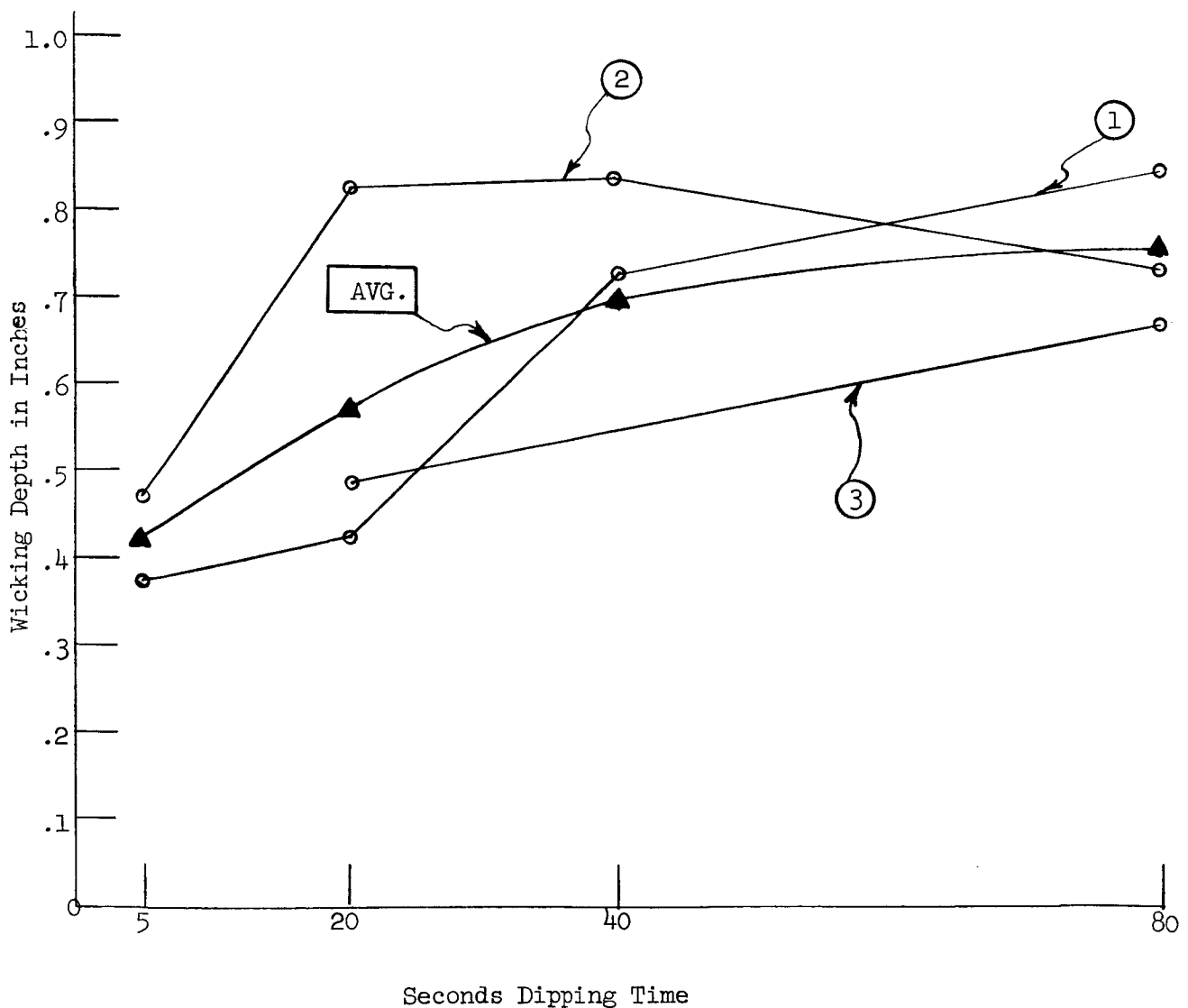
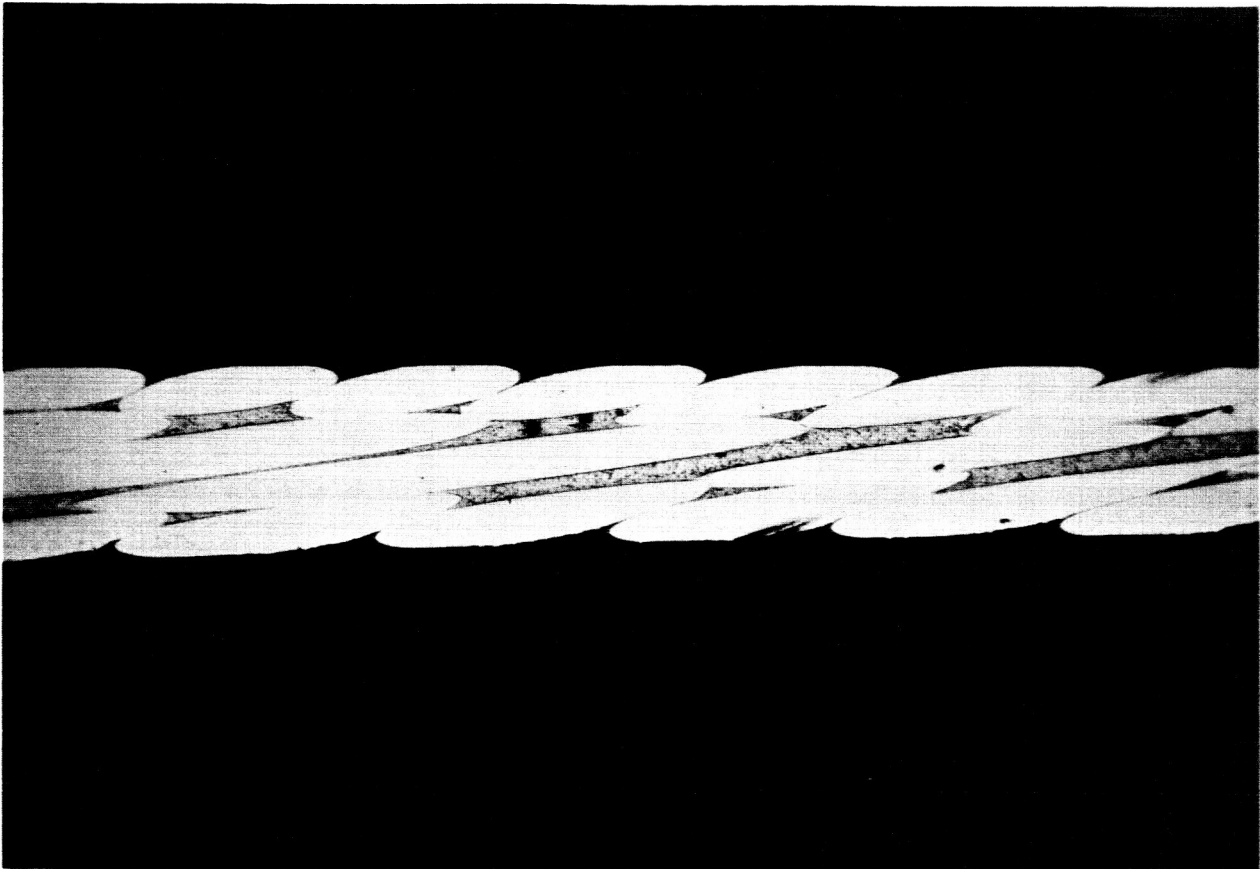


Figure 7-3: Wicking Depth and Immersion Time at 550°F

FIGURE 7-4



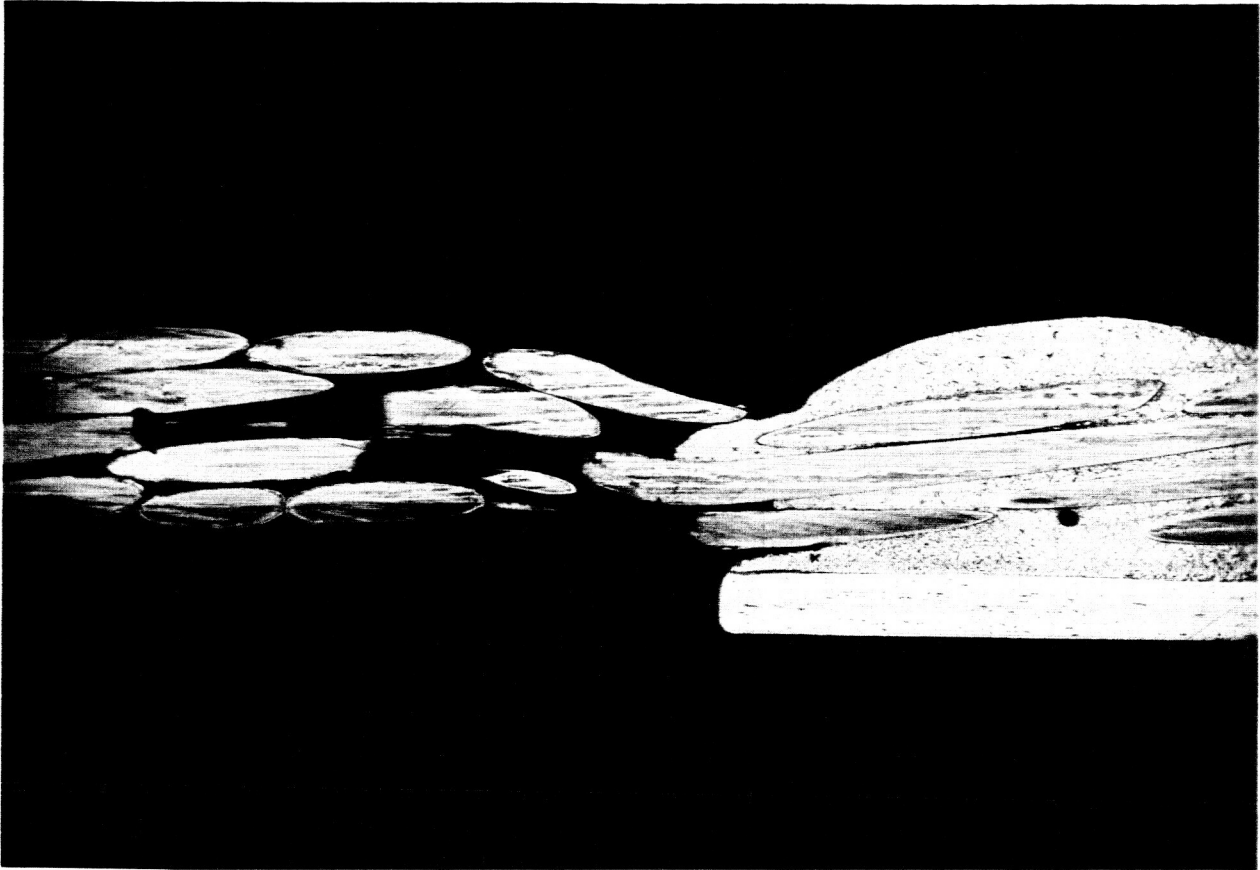
IMSC Laboratory No. 57922  
Test Series A1-A4

Negative No. 24087  
Magnification 50X

Longitudinal Section - Nickel-plated copper wire, 19 strand, 22 AWG. with  
Teflon insulation

Wicking after immersion in 60/40 tin-lead solder at 400°F for 80 seconds.

FIGURE 7-5



IMSC Laboratory No. 58595  
Test Series A29

Negative No. 24592  
Magnification 32X

Longitudinal Section - Nickel-plated copper wire, 19 strand, 22 AWG. with Teflon insulation.

Hand soldered to connector pin, using Alpha Metals 60/40 solder with N.R.G. Flux Core, with "Little Joe" heat sink. Note: No wicking occurred between strands.

Figure 7-6 shows a specimen from test series A30, duplicating A29 but without use of a heat sink. The solder wicked through the entire visible length of the wire.

Figures 7-7 and 7-8 show one specimen each of the similar test series A31 and A32, where a 7 strand, 24AWG, nickel-plated copper wire was soldered into connector pins, both with and without the heat sink application. The specimen with the heat sink shows no wicking.

7.6.2 Fatigue Resistance Tests. As described in section 9, paragraph 9.3, fatigue resistance testing was performed by cycling the stranded wire specimen under a constant load of one (1) pound, through an angle of  $\pm 55^\circ$  from the vertical until failure occurred.

The test details are recorded in the individual Test Data Sheets in section 9, paragraph 9.4. Results are summarized in the chart on page 7-17 and 7-18 depicted graphically in Figure 7-9, page 7-18.

Results indicate that for nickel and silver-plated strands:

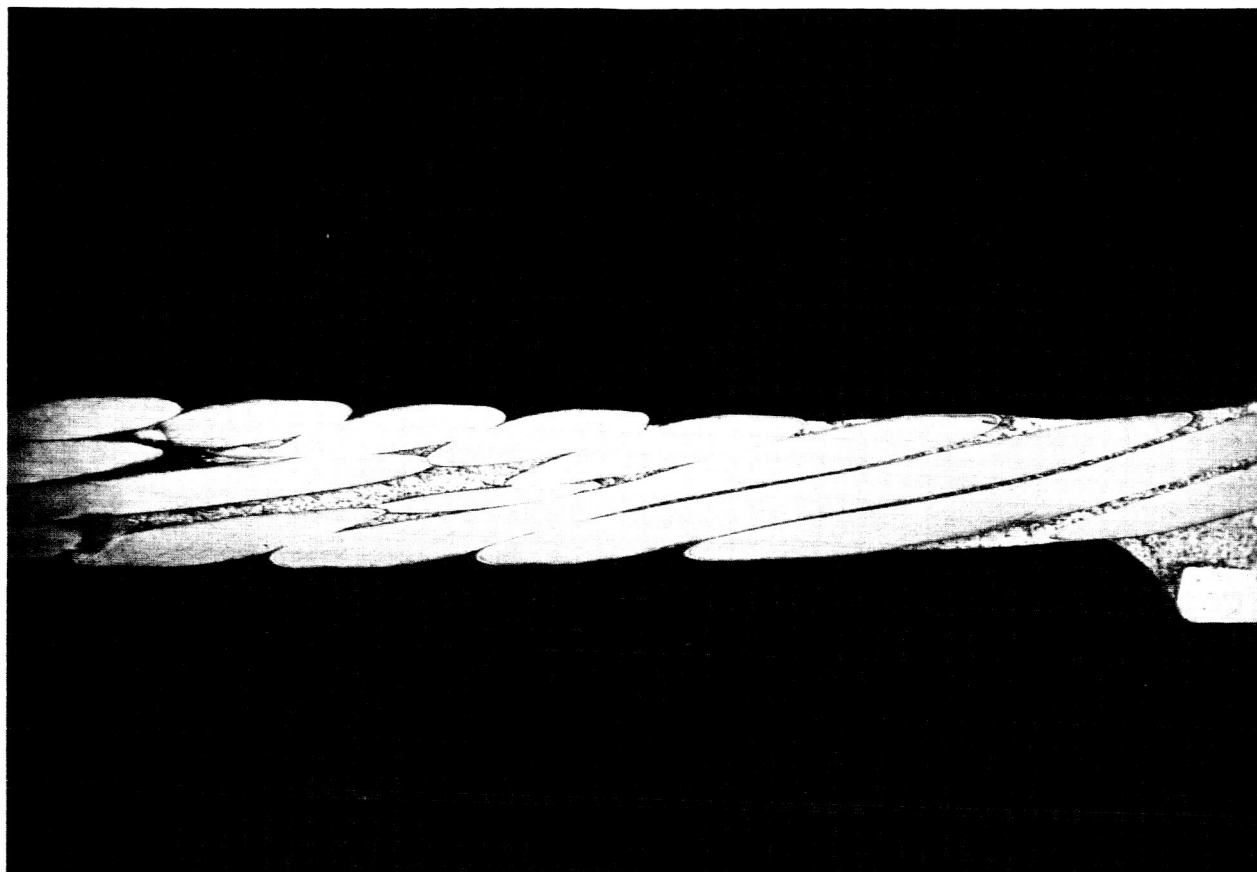
- Fatigue resistance decreases slightly with increasing dip temperature of the solder bath.
- Fatigue resistance decreases with increased dipping time in the solder bath.

Comparing nickel and silver as plating materials, it becomes obvious that:

- The loss of fatigue resistance with silver-plated cable is approximately twice as great as that for a nickel-plated cable of the same dimensions.

Metallurgically, this is attributed to the fact that the diffusion coefficient of silver into copper is several orders of magnitude greater than that of nickel into copper and that the copper-rich phase has low ductility.

FIGURE 7-6



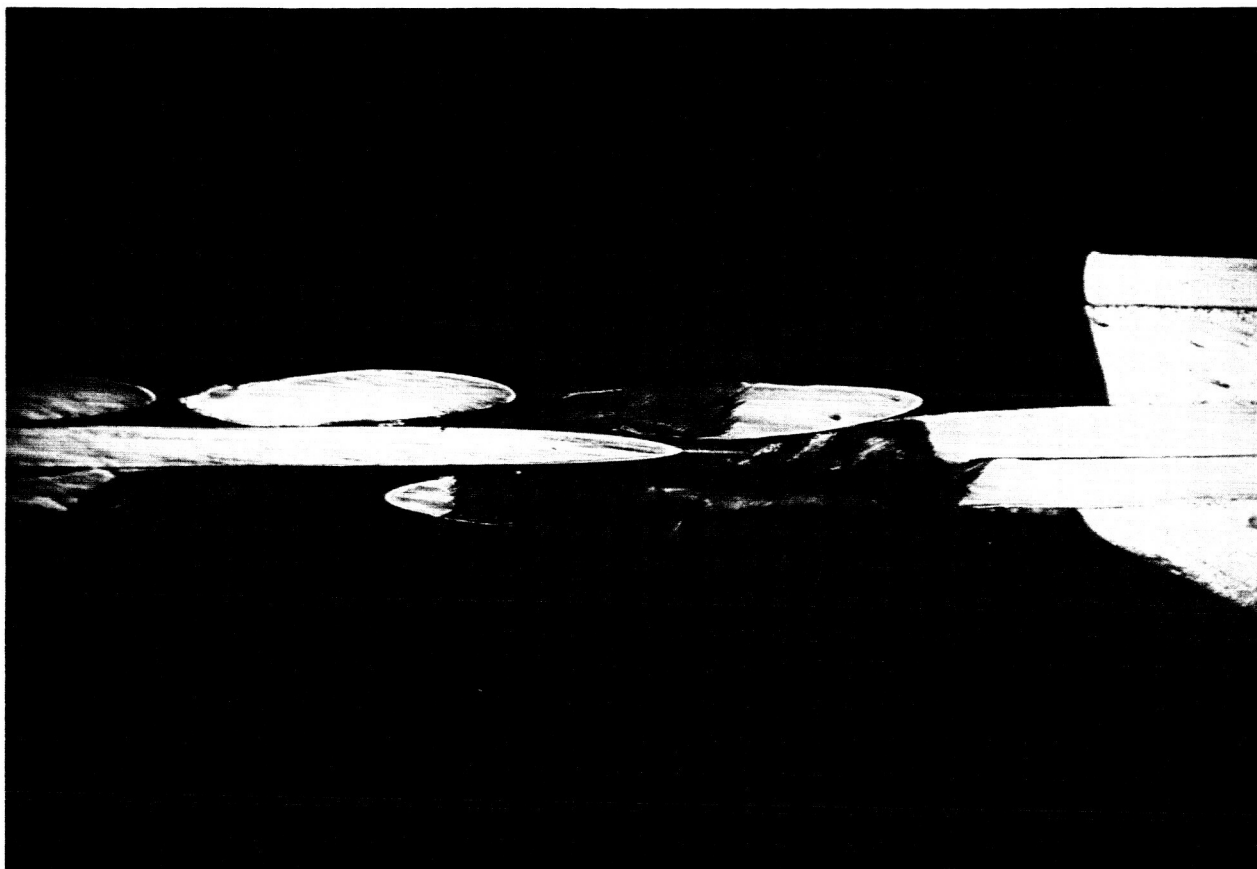
LMSC Laboratory No. 58595  
Test Series A30

Negative No. 24593  
Magnification 32X

Longitudinal Section - Nickel-plated copper wire, 19 strand, 22 AWG., with Teflon insulation.

Hand soldered to connector pin, using Alpha Metals 60/40 solder with N.R.G. Flux Core, without heat sink. Note: Wicking occurred through the entire length of the wire shown.

FIGURE 7-7



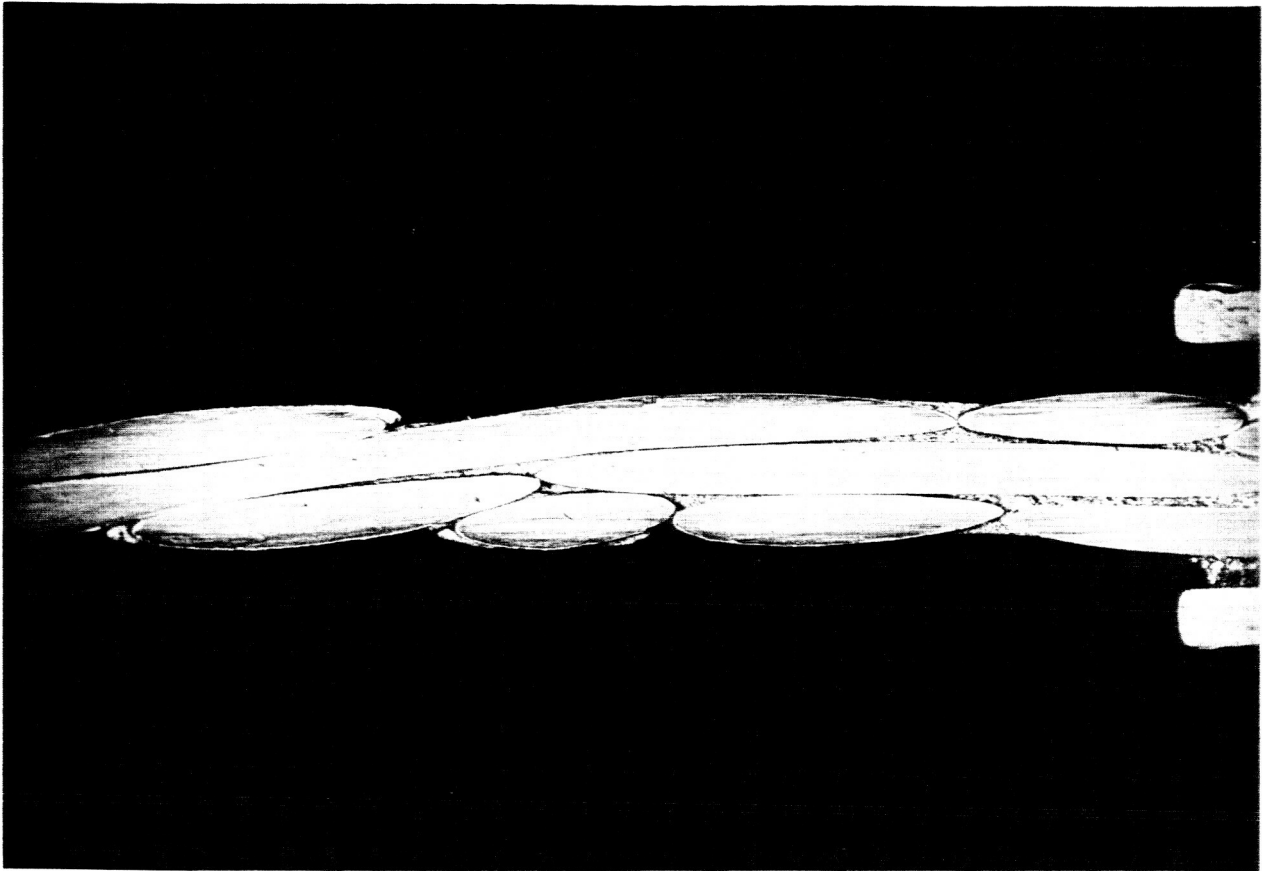
LMSC Laboratory No. 58595  
Test Series A31

Negative No. 24594  
Magnification 32X

Longitudinal Section - Nickel-plated copper wire, 7 strand, 24 AWG, with Teflon insulation.

Hand soldered to connector pin, using Alpha Metals 60/40 solder with N.R.G. Flux Core, with "Little Joe" heat sink. Note: No wicking occurred between strands.

FIGURE 7-8



IMSC Laboratory No. 58595  
Test Series A32

Negative No. 24595  
Magnification 32X

Longitudinal Section - Nickel-plated copper wire, 7 strand, 24 AWG., with Teflon insulation

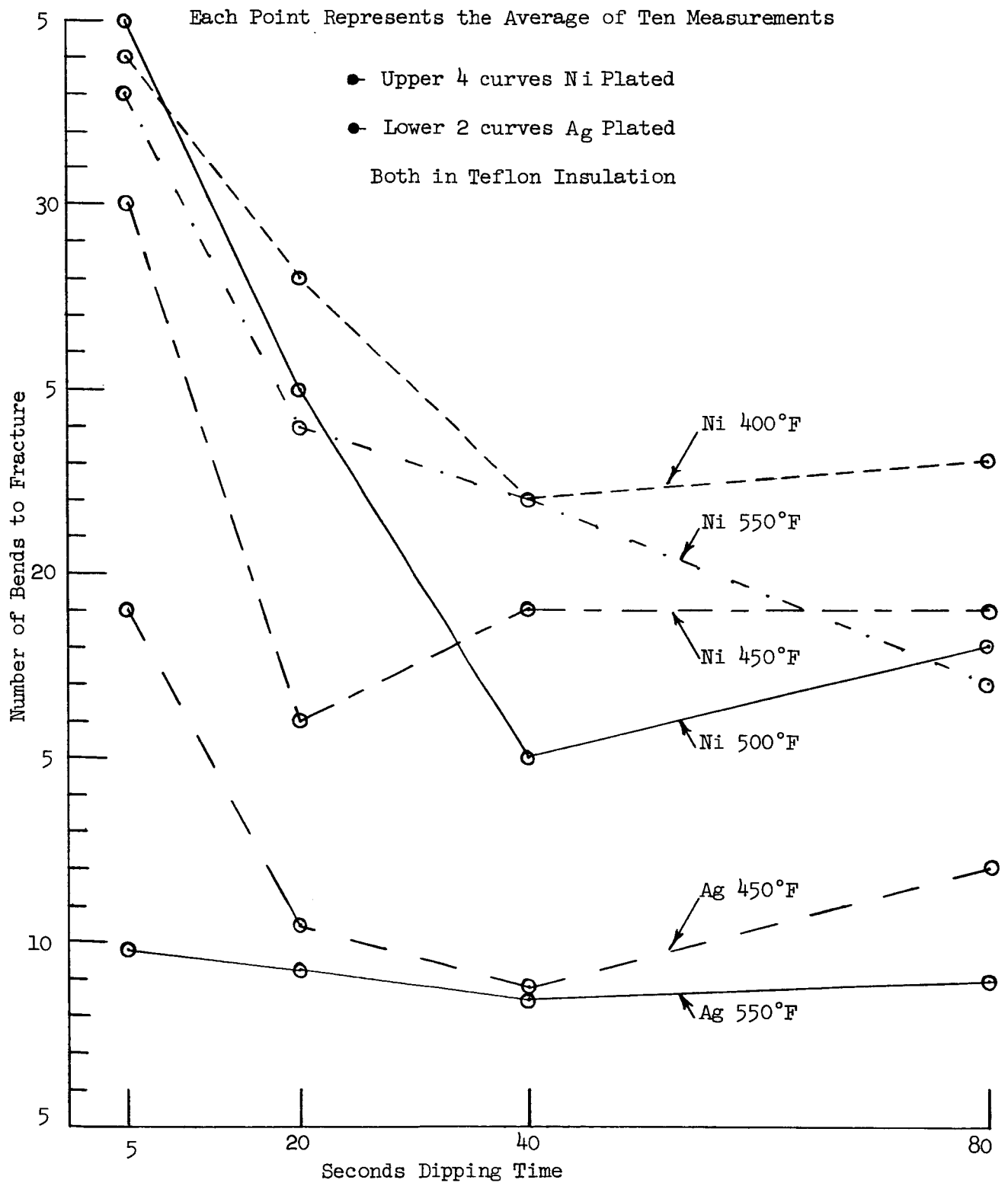
Hand soldered to connector pin, using Alpha Metals 60/40 solder with N.R.G. Flux Core, without heat sink. Note: Wicking occurred through almost the entire length of wire.

FATIGUE RESISTANCE TESTSSUMMARY

STRANDED CABLE		Plat'G	DIPPING TIME AND TEMPERATURE					CABLE AS IS
Strands	AWG.		Temperature	5 Sec.	20 Sec.	40 Sec.	80 Sec.	
19	22	Nickel	400°F	34	28	22	23	52
19	22	Nickel	450°F	30	16	19	19	52
19	22	Nickel	500°F	35	25	15	18	52
19	22	Nickel	550°F	33	24	22	17	52
19	22	Silver	450°F	19	10	9	12	56
19	22	Silver	550°F	10	9	8	9	56
7	24	Nickel	450°F	--	12	--	9	26
7	24	Nickel	550°F	--	10	--	9	26

NOTE: The figures given indicate the number of cycles to failure. All results shown were obtained on wicked cable ends only. Tests on connector pins are not included.

Figure 7-9: Fatigue Testing 19 Strand - 22 AWG Copper Wire



As mentioned earlier in paragraph 7.6.1, operator variations in twisting force which occur during the stripping procedure affect the capillary distance between the wire strands. This, in turn, causes variations of wicking length. This can only be eliminated by using a mechanically controlled stripping tool with constant twisting force or by a heat sink which eliminates wicking.

## Section 8

### SUMMARY

#### SUBTASK (g) - JOINT TENSILE STRENGTH

- Purpose. The purpose of this investigation is to determine the influence of stranded wire plating and insulation on the pull strength of soldered joints.

Based on the results, recommendations shall be made for optimum combinations of wire plating and insulation.

- Results:
  - The type of plating materials for copper strands does not significantly affect the pull strength of the soldered joint, assuming adequate tinning is applied.
  - The type of insulation material has no effect on pull strength of the soldered joints.
  - Pre-tinning of nickel-plated cable can be accomplished with a sufficiently activated flux. However, the ever-present corrosion potential, particularly over long time intervals must be recognized whenever nickel is used as a coating for copper.
  - Silver and solder coating presented no unusual pre-tinning problems. However, it is important to consider the potential danger of lowered fatigue resistance of silver-coated copper wires.

- Specimens fractured in the heat affected wicked zone of the wire, adjacent to the joint, not in the joint.
  - Reduction of fatigue resistance by wicking degrades reliability of the joint seriously.
  - Thermal wire stripping leaves irregular termination of cable insulation.
  - Thermal wire stripping seemingly leaves more residual insulation on stripped wire than mechanical stripping.
  - Small voids in a solder cup connection do not affect the mechanical strength of the joint.
- Recommendations.
    - Avoid nickel as copper wire plating material.
    - If nickel must be used, apply activated flux to provide adequate tinning.
    - Use heat sink during soldering to avoid degradation of joints by reduced fatigue resistance.
    - Use mechanical wire stripping rather than thermal wire stripping, particularly with Teflon insulation.
    - Investigations should be made of the integrity of joints prepared with hydrazine-containing solder flux and develop adequate post solder cleaning methods.

## SECTION 8

### SUBTASK (g)

#### 8.0 JOINT TENSILE STRENGTH

##### 8.1 Objective

The objective of subtask (g) was to analyze and compare joint integrity of soldered connections as a function of specific stranded wire and insulation material combinations when subjected to laboratory testing.

##### 8.2 Test Description

8.2.1 Basic Test Configuration. Two (2) basic test configurations were used for this subtask. These were:

- Stripped stranded cable ends assembled to turret terminals by hand soldering
- Stripped stranded cable ends assembled to connector pins by hand soldering cable into pin-well

A total of 975 specimen solder connections were used. These were subdivided into 17 test series. Preparation of the test specimen is described in paragraph 8.3.1.

8.2.2 Stripping of Insulation. Insulation removal, prior to cleaning and soldering, was performed in two (2) ways:

- Originally by thermal stripping, using an LMSC Standard thermal stripper tool manufactured by American Missile Products Company.

- During the second part of the investigation, mechanical stripping was used. The tool was a Model 45-174 Mechanical Wire Stripper with blade #L-5563; both were made by Ideal Industries, Inc., Sycamore, Illinois.

8.2.3 Cleaning of Stripped Cable Ends. The stripped cable ends were cleaned prior to soldering by immersion in either trichloroethylene, TMC Freon, or chloroethane and scrubbing with bristle brush during immersion.

8.2.4 Cleaning of Connector Pins and Terminals. Connector pins and terminals were cleaned by vapor degreasing for two (2) to five (5) minutes in a commercial model vapor degreaser.

### 8.3 Test Specimen Preparation

8.3.1 Test Specimen Description. Test specimens consisted of stranded copper cables, plated with various protective metals and insulated with different insulating materials. Pieces of cable approximately 8" long were stripped by either one of the two methods described in par. 8.2.2, cleaned as described in par. 8.2.3, and then hand soldered into the connector pin-wells or around turret terminals.

8.3.2 Solder/Flux Combinations. For the bulk of these tests, only two solder/flux combinations were used:

- ALPHA METALS 60/40 solder with plastic flux core (non-activated)
- ALPHA METALS 60/40 solder with NRG flux core (activated)

Hydrazine-activated flux is presently not approved for use on electronic circuitry, due to its very strong action. However, for comparison purposes, an additional test series was made using:

- FAIRMOUNT 60/40 H-32 flux core solder (hydrazine-activated)

#### 8.4 Materials and Test Equipment

8.4.1 Test Specimen Materials. Specimen materials were selected to enable the testing of various sizes of copper stranded wire with different silver, nickel, and solder plating combinations with Teflon and Vinyl as insulation materials.

Wires used are shown in the table below:

AWG.	No. of Strands	Teflon Insul.		Vinyl Insul.		
		Silver	Nickel	Silver	Nickel	Solder
18	19	X		X		X
22	19	X	X	X		
24	7	X	X		X	X
28	7	X	X	X	X	X

For details and suppliers of these wires, see section 9, par. 9.1.

Pins used were:

#162 for cable AWG 18, MIL-C-26482, goldplated  
 #206 for cables AWG 22, 24, 28 MIL-C-26482, goldplated

Turrets used were:

LS-8958-2 for cables AWG 24 and 28  
 commercial brand per QQ-B626, solder plated per MIL-F-14072,  
 Finish #M-259

The solder/flux combinations are described in par. 8.3.2.

#### 8.4.2 Test Equipment and Cleaning Materials

- Instron Pull Tester  
See section 4, par. 4.1.3, (IMSC/A731415)
- Humidity Test Chamber  
See section 4, par. 4.1.4, (IMSC/A731415)
- Cleaning Solvents  
See section 9, par. 9.2

#### 8.5 Test Data and Records

The purpose of subtask (g) was to study the influence of various plating materials and insulation materials specified for the manufacture of stranded wires on joint tensile strength; emphasis was placed on determining the mechanical and metallurgical joint quality. This was achieved by: measuring the joint tensile strength before and after corrosion at 95°F under 95% Relative Humidity and determining the fatigue resistance; and cross-sectioning representative specimens of each test series and subjecting them to metallurgical examination.

Test data are recorded in individual Test Data Sheets (see section 9, par. 5 ). These Data Sheets contain all information pertinent to the test specimen preparation. Immediately following each Test Data Sheet are reproductions of the photographs and photomicrographs which illustrate the results obtained.

#### 8.6 Test Results

The numerical results of all tests made in the study of joint tensile strength are summarized in Table 8-1. The contents are grouped by test specimen dimensions, because it is those dimensions which determine primarily the pull strength of any particular combination. The sub-grouping under each heading is by wire plating material (first independent variable) and then by insulation material (second independent variable).

FIGURE 8-1JOINT TENSILE STRENGTH

TEST SERIES	PIN OR TURRET	STRANDED WIRE			INSULATION	BEFORE	AFTER
		AWG	STRANDS	PLATING		CORROSION TEST	
G-7	#162	18	19	Silver	Teflon	56.15 0.28	55.59 0.34
G-15				Silver	Vinyl	56.58 0.378	55.89 0.218
G-5				Solder	Vinyl	50.48 8.92	51.29 6.53
G-1	#202	22	19	Silver	Teflon	21.97 0.092	21.88 1.97
G-14				Silver	Vinyl	22.94 0.142	22.10 0.93
G-11				Nickel	Teflon	24.77 0.680	24.81 0.327
G-2	#202	24	7	Silver	Teflon	12.70 0.079	12.64 0.091
G-8				Nickel	Teflon	0	--
G-9				Nickel	Teflon	15.17 0.405	15.08 0.084
G-16				Nickel	Vinyl	14.65 0.116	14.83 0.134
G-12	#202	28	7	Silver	Vinyl	5.40 0.683	5.30 0.982
G-17				Nickel	Vinyl	5.66 0.057	5.74 0.070
G-3				Solder	Vinyl	5.88 0.77	6.01 0.098

FIGURE 8-1  
(cont.)

TEST SERIES	PIN OR TURRET	STRANDED WIRE				BEFORE	AFTER
		AWG	STRANDS	PLATING	INSULATION	CORROSION TEST	
G-4	8958-2	24	7	Solder	Vinyl	8.45 1.48	9.02 1.43
G-6	8958-2	28	7	Silver	Teflon	4.31 0.39	4.05 0.49
G-13				Silver	Vinyl	5.2 0.886	5.4 0.771
G-10				Nickel	Telfon	4.42 0.716	4.14 0.747

As to preparation of the samples, it should be noted that:

- heating of solder cup from upper end was used in test series G-1, 2, 3, 5, 7, 8, 9, and 11,
- heating of solder cup from lower end was used in test series G-12, 14, 15, 16, and 17,
- thermal stripping was used in test series G-1, through G-2.
- mechanical stripping was used in test series G-12 through G-17

8.6.1 Various Plating Materials. Compared were silver, nickel, and solder as plating materials for the copper strands under the insulation.

8.6.1.1 Insulation Teflon

22 AWG - 19 strand wire, plated as shown, bonded to #202 connector pins with Alpha Metals 60/40 Plastic Core solder (G-1) or Alpha Metals 60/40 N.R.G. Core solder (G-2.)

Test Series	Plating	Average Pull Strength & Sigma	
		Before Corrosion	After Corrosion
G-1	Silver	$\bar{x}$ = 21.97 lb. $\sigma$ = 0.092 lb.	$\bar{x}$ = 21.88 lb. $\sigma$ = 1.97 lb.
G-2	Nickel	$\bar{x}$ = 24.77 lb. $\sigma$ = 0.68 lb.	$\bar{x}$ = 24.81 lb. $\sigma$ = 0.327 lb.

Pull strength results and visual inspections show absence of corrosion after the humidity test. Sixteen percent of the specimens in Test Series G-1 fractured in the joint; the remaining 84% fractured adjacent to the joint in the wicked part of the stranded cable. All specimens of Test Series G-2 broke in the wicked part of the cable. The variation in pull strength average for cables with silver and nickel-plated strands is due to the physical properties of the cable. Without knowing the precise history of the cable manufacturing procedure, explanation of these results cannot be made in this study.

Figures 8-2 and 8-34 show enlarged views of randomly selected joints. The uneven edge of the Teflon insulation is due to the use of a thermal wire stripper. Figures 8-3 and 8-4 are sections through samples from series G-1. Voids in the solder cup indicate poor wetting. This phenomenon is attributed to use of non-activated flux and to heating of the solder cup from the upper rim instead of from the bottom. Figs. 8-35/36 (Series G-2) show that this condition can be improved through use of an activated flux.

#### 8.6.1.2 Insulation Teflon

24 AWG. 7 strand wire, plated as shown, bonded to #202 connector pin with Alpha Metals 60/40 N.R.G. Core solder.

Test Series	Plating	Average Pull Strength & Sigma	
		Before Corrosion	After Corrosion
G-2	Silver	$\bar{x}$ = 12.70 lb.	$\bar{x}$ = 12.66 lb.
		$\sigma$ = 0.079 lb.	$\sigma$ = 0.091 lb.
G-9	Nickel	$\bar{x}$ = 15.17 lb.	$\bar{x}$ = 15.08 lb.
		$\sigma$ = 0.405 lb.	$\sigma$ = 0.084 lb.

All specimens of both test series fractured in the wicked portion of the stranded cable; no cables pulled out of the soldered joint.

Visual inspection and pull strength results indicate absence of corrosion caused by humidity testing.

Figures 8-5 and 8-29 show close-up views of soldered specimens. The fillet formation is satisfactory. Figures 8-6 and 8-7 (test series G-2 only) indicate incomplete wetting and voids in the solder cups. However, Figures 8-29 and 8-30 (test series G-9) indicate considerably improved joint conditions with almost no voids visible. Since no basic change of procedure was introduced during this time, the improvement is attributed to better training of the operator and to the use of a 3X magnifier during test specimen fabrication.

## 8.6.1.3 Insulation Teflon

28 AWG. - 7 strand wire, plated as shown, bonded to #8958-2 turret terminal with Alpha Metals 60/40 Plastic Core solder (G-6) or Alpha Metals 60/40 N.R.G. Core solder (G-10)

Test Series	Plating	Average Pull Strength & Sigma	
		Before Corrosion	After Corrosion
G-6	Silver	$\bar{x}$ = 4.31 lb.	$\bar{x}$ = 4.05 lb.
		$\sigma$ = 0.39 lb.	$\sigma$ = 0.49 lb.
G-10	Nickel	$\bar{x}$ = 4.42 lb.	$\bar{x}$ = 4.14 lb.
		$\sigma$ = 0.716 lb.	$\sigma$ = 0.747 lb.

All specimens of both test series broke at the joints under loads approximately 54% smaller than the breaking load of the stranded wire itself. Breaking loads and visual inspection indicate no corrosion due to the humidity test.

Figures 8-19 and 8-31 show close-up views of randomly selected samples from both test series. Fillet formation is satisfactory.

Figures 8-19, 8-20, and 8-21 (test series G-6) and Figures 8-32 and 8-33 (test series G-10) show good wetting and satisfactory joints.

The fatigue tests indicate that wicking on joints of this type results in a decreased resistance to flexure fatigue.

## 8.6.1.4 Insulation Vinyl

18 AWG - 19 strand wire, plated as shown, bonded to #162 connector pin with Alpha Metals 60/40 Plastic Core solder

Test Series	Plating	Average Pull Strength & Sigma	
		Before Corrosion	After Corrosion
G-15	Silver	$\bar{x}$ = 56.58 lb. $\sigma$ = 0.378 lb.	$\bar{x}$ = 55.89 lb. $\sigma$ = 0.218 lb.
G-5	Solder	$\bar{x}$ = 50.48 lb. $\sigma$ = 8.92 lb.	$\bar{x}$ = 51.29 lb. $\sigma$ = 6.53 lb.

All specimens of these test series failed adjacent to the soldered joint in the wicked portion of the stranded wire. These failures occurred at loads approximately 93% of the breaking load of the wire. The 12% difference in pull strength between the silver-plated and solder-plated specimens is attributed to the physical properties of the wires and cannot be explained without detailed metallurgical investigations beyond the scope of this contract.

Pull strength and visual inspection before and after humidity testing indicate absence of corrosion effects.

Specimens of test series G-5 were assembled by heating the solder cup from the upper end, while specimens of test series G-15 were prepared by applying the heat from the lower end of the solder cup. The stripping procedures for the insulation was also changed from thermal stripping to mechanical stripping (see par. 8.2.2). This change is clearly reflected in the photographs and photomicrographs presented.

Figures 8-15, 8-16, and 8-17 show representative specimens of test series G-5 where thermal stripping and heating of the pin well from the top was used.

Figures 8-47, 8-48, and 8-49 show representative test specimens of test series G-15, where mechanical stripping and heating of the pin well from the bottom were used. The improvement of this method over that of heating

from the top is evident.

#### 8.6.1.5 Insulation Vinyl

28 AWG - 7 strand wire, plated as shown, bonded to #202 connector pins with Alpha Metals 60/40 N.R.G. Core solder (G-3 and G-12) or Fairmount 60/40 H-32 Core solder (G-17)

Test Series	Plating	Wire Only (lb.)	Average Pull Strength & Sigma	
			Before Corrosion	After Corrosion
G-12	Silver	9.20	$\bar{x}$ = 5.40 lb. $\sigma$ = 0.683 lb.	$\bar{x}$ = 5.30 lb. $\sigma$ = 0.982 lb.
G-17	Nickel	7.26	$\bar{x}$ = 5.66 lb. $\sigma$ = 0.057 lb.	$\bar{x}$ = 5.74 lb. $\sigma$ = 0.070 lb.
G-3	Solder	8.90	$\bar{x}$ = 5.88 lb. $\sigma$ = 0.77 lb.	$\bar{x}$ = 6.01 lb. $\sigma$ = 0.098 lb.

Results of these test series indicate that plating of the copper wire has no influence on joint strength. Test specimens of these groups broke outside the joint in the wicked portion of the cable at loads of 59%, 78% and 66% of the stranded wire breaking load for silver, nickel, and solder plating respectively.

Figures 8-8, 8-37, and 8-53 show the outer appearance of one joint from each of the three groups.

Figures 8-9, 8-38, and 8-54 show transverse sections through one specimen of each of the three groups; and Figures 8-10, 8-39, and 8-55 show longitudinal sections through the connector pins. The absence of voids, after changing the heating procedure and applying activated flux, is evident.

Pull strength values and visual inspection before and after the humidity test prove absence of corrosion.

## 8.6.2 Various Insulation Materials

Teflon and Vinyl were compared as insulation materials over silver and nickel plated strands.

### 8.6.2.1 Plating Silver

22 AWG - 19 strand wire, insulation as shown, bonded to #202 connector pins with Alpha Metals 60/40 Plastic Core solder

Test Series	Insulation	Average Pull Strength & Sigma	
		Before Corrosion	After Corrosion
G-1	Teflon	$\bar{x}$ = 21.97 lb.	$\bar{x}$ = 21.88 lb.
		$\sigma$ = 0.092 lb.	$\sigma$ = 1.97 lb.
G-14	Vinyl	$\bar{x}$ = 22.94 lb.	$\bar{x}$ = 22.10 lb.
		$\sigma$ = 0.142 lb.	$\sigma$ = 0.93 lb.

Sixteen percent of the specimens of test series G-1 broke in the soldered joint by pulling the wire out. The remainder of the test specimens of this series and all specimens of series G-14 broke in the wicked portion of the wire outside of the soldered joint.

Pull strength averages indicate no significant difference in solder joint strength values between Teflon and Vinyl insulated stranded wires. The results indicate also, that no corrosion occurred due to humidity testing.

Details of specimens from series G-1 are shown in Figures 8-2, 8-3, and 8-4. Figure 8-44 shows a magnified view of one connector pin, while Figures 8-45 and 8-46 give transversal and longitudinal sections through soldered joints. From the photomicrographs, it becomes apparent that several small voids exist in the joints. However, their presence is attributed to use of Plastic Core flux which is a non-activated rosin flux.

## 8.6.2.2 Plating Silver

28 AWG - 7 strand wire, insulation as shown, bonded to #8958-2 turret terminals with Alpha Metals 60/40 Plastic Core solder (G-6) or Alpha Metals 60/40 N.R.G. Core solder (G-13)

Test Series	Insulation	Average Strength & Sigma	
		Before Corrosion	After Corrosion
G-6	Teflon	$\bar{x}$ = 4.31 lb. $\sigma$ = 0.39 lb.	$\bar{x}$ = 4.05 lb. $\sigma$ = 0.49 lb.
G-13	Vinyl	$\bar{x}$ = 5.20 lb. $\sigma$ = 0.886 lb.	$\bar{x}$ = 5.40 lb. $\sigma$ = 0.771 lb.

All specimens of series G-6 and G-13 broke outside of the soldered joint in the wicked portion of the stranded wire. The difference in average pull strength between the Teflon and Vinyl insulated samples is attributed to use of activated flux in the case of G-13 rather than to the difference in insulation material. As shown in the photomicrographs (see below), wetting is better with activated flux.

Visual inspection and pull strength indicates no corrosion due to the humidity test.

Photomicrographs of test series G-6 specimens are presented in Figures 8-18, 8-19, 8-20, and 8-21, and have been discussed in par. 8.6.1.3, page

Figures 8-40, 8-41, 8-42, and 8-43 show a magnified view and sections through typical specimens of series G-13. All pictures demonstrate perfect wetting.

## 8.6.2.3 Plating Silver

18 AWG. - 19 strand wire, insulation as shown, bonded to #162 connector pins with Alpha Metals 60/40 N.R.G. Core solder (G-7) or Alpha Metals 60/40 Plastic Core solder (G-15).

Test Series	Insulation	Average Pull Strength & Sigma	
		Before Corrosion	After Corrosion
G-7	Teflon	$\bar{x}$ = 56.15 lb. $\sigma$ = 0.28 lb.	$\bar{x}$ = 55.95 lb. $\sigma$ = 0.34 lb.
G-15	Vinyl	$\bar{x}$ = 56.58 lb. $\sigma$ = 0.378 lb.	$\bar{x}$ = 55.89 lb. $\sigma$ = 0.218 lb.

All specimens broke outside of the soldered joint in the wicked part of the stranded wire. The breaking load was approximately 93% of that of the stranded wire itself. The figures demonstrate that no significant difference exists between wires with Teflon and Vinyl insulation.

The very slight decrease of average pull strength after the humidity test is not significant enough to indicate an occurrence of corrosion. Figures 8-22, 8-23, and 8-24 show representative photomicrographs of test series G-7 specimens. Some small voids are visible in the cup.

Figures 8-47, 8-48, and 8-49, depict specimens from test series G-15. As mentioned earlier (paragraph 8.6, page 8-9), this test series was prepared by heating the solder cups from the bottom, which results in formation of a joint with fewer voids.

#### 8.6.2.4 Plating Nickel

24 AWG. - 7 strand wire, insulation as shown, bonded to #202 connector pins with Alpha Metals 60/40 N.R.G. Core solder

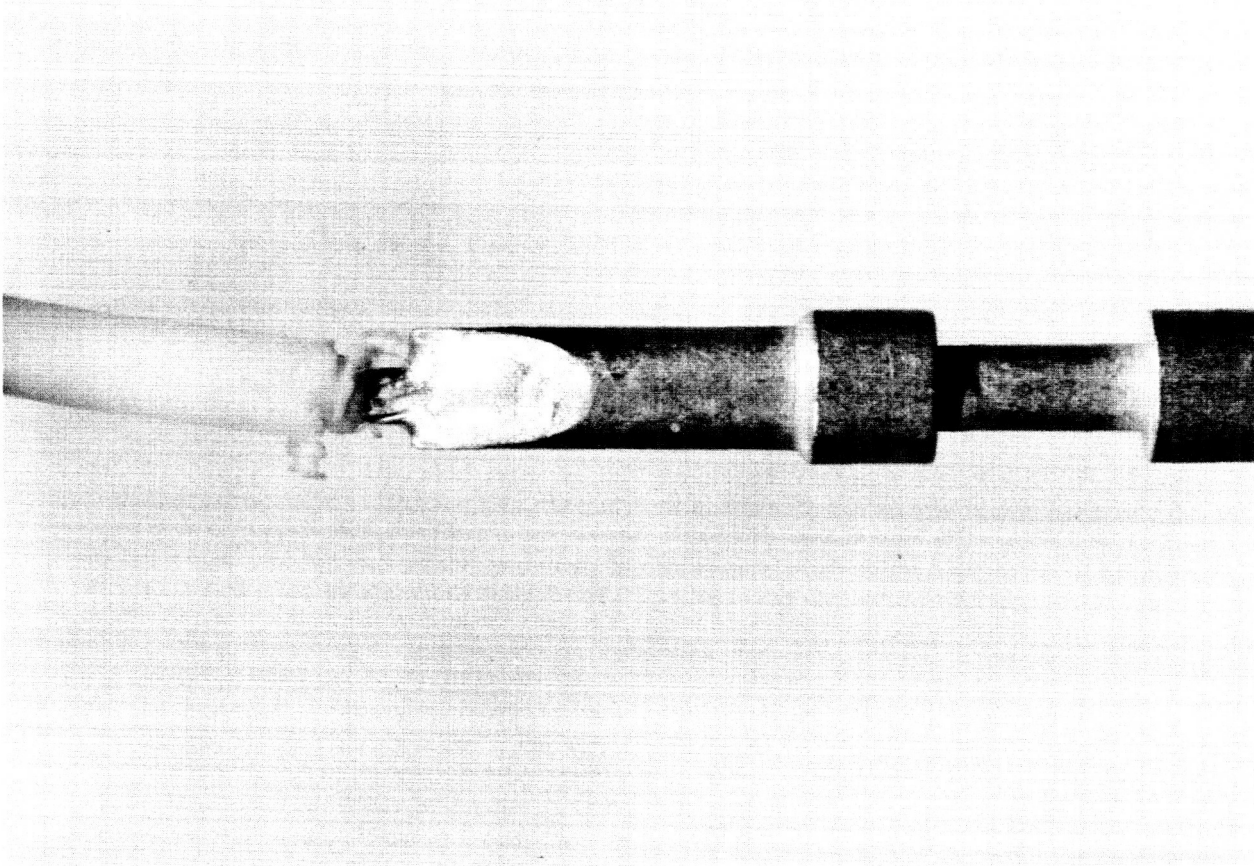
Test Series	Insulation	Average Pull Strength & Sigma	
		Before Corrosion	After Corrosion
G-9	Teflon	$\bar{x}$ = 15 17 lb. $\sigma$ = 0.405 lb.	$\bar{x}$ = 15.08 lb. $\sigma$ = 0.084 lb.
G-16	Vinyl	$\bar{x}$ = 14.65 lb. $\sigma$ = 0.116 lb.	$\bar{x}$ = 14.85 lb. $\sigma$ = 0.134 lb.

All specimens prepared in test series G-9 and G-16 fractured outside the soldered joint in the stranded wire at a load below that for the untreated wire itself. The average pull strength figures indicate that no significant difference exists between Teflon-insulated and Vinyl-insulated wire. It is also obvious that the humidity test caused no detectable corrosion.

Photomicrographs of specimens from test series G-9 are presented in Figures 8-28, 8-29, and 8-30. They are discussed in par. 8.6.1.2.

Figures 8-50, 8-51, and 8-52 show photomicrographs of typical specimens from test series G-16. The pictures indicate absence of voids and good fillets and joints.

FIGURE 8-2



IMSC Lab. No. 56192-1  
Test Series No. G-1

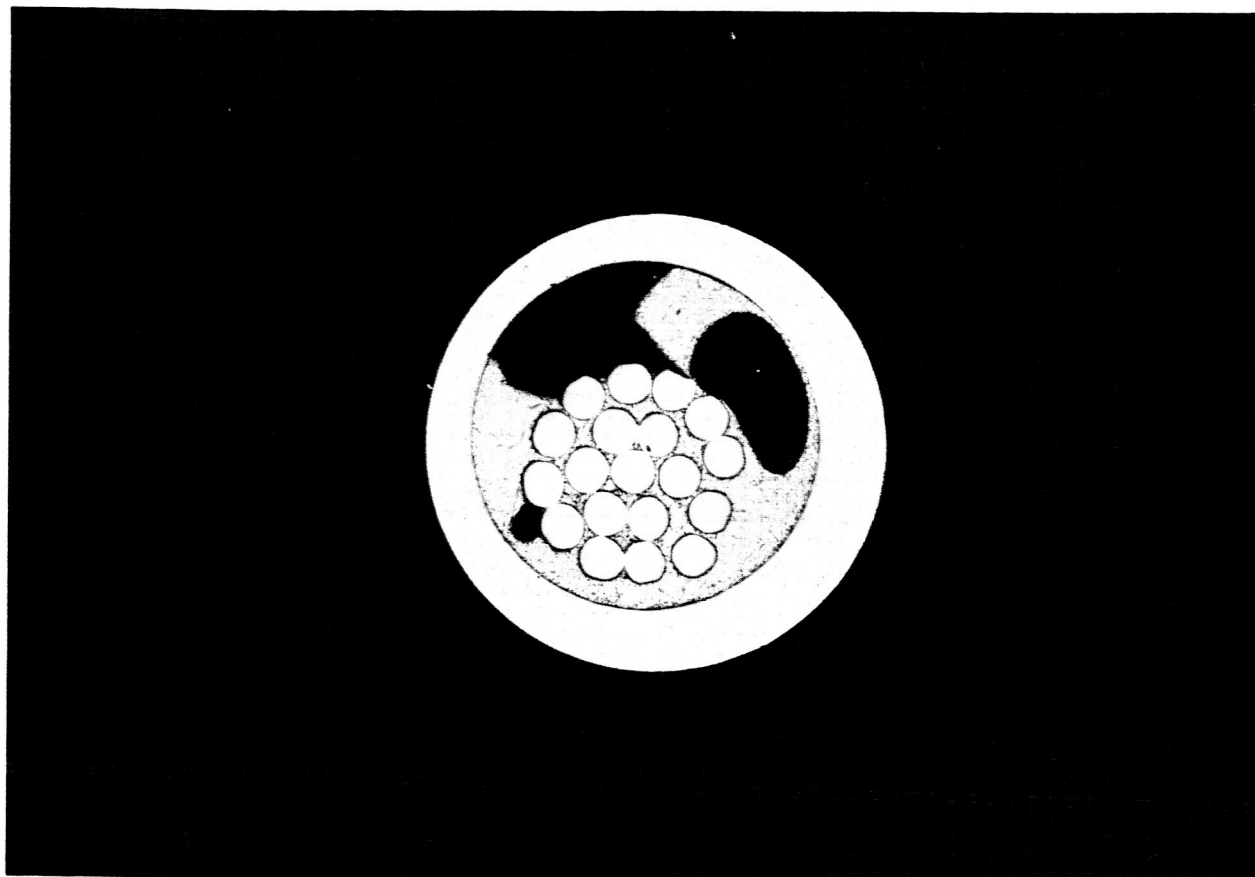
IMSC Negative No. 22848  
Magnification 9x

Enlarged view of soldered joint.

22 AWG-19 strand copper wire, silver plated, Teflon insulation, soldered into cup of #202 connector pin, using Alpha Metals 60/40 Plastic Core solder.

Note: Uneven insulation termination, due to thermal stripping.

FIGURE 8-3



IMSC Lab. No. 56192-1  
Test Series No. G-1

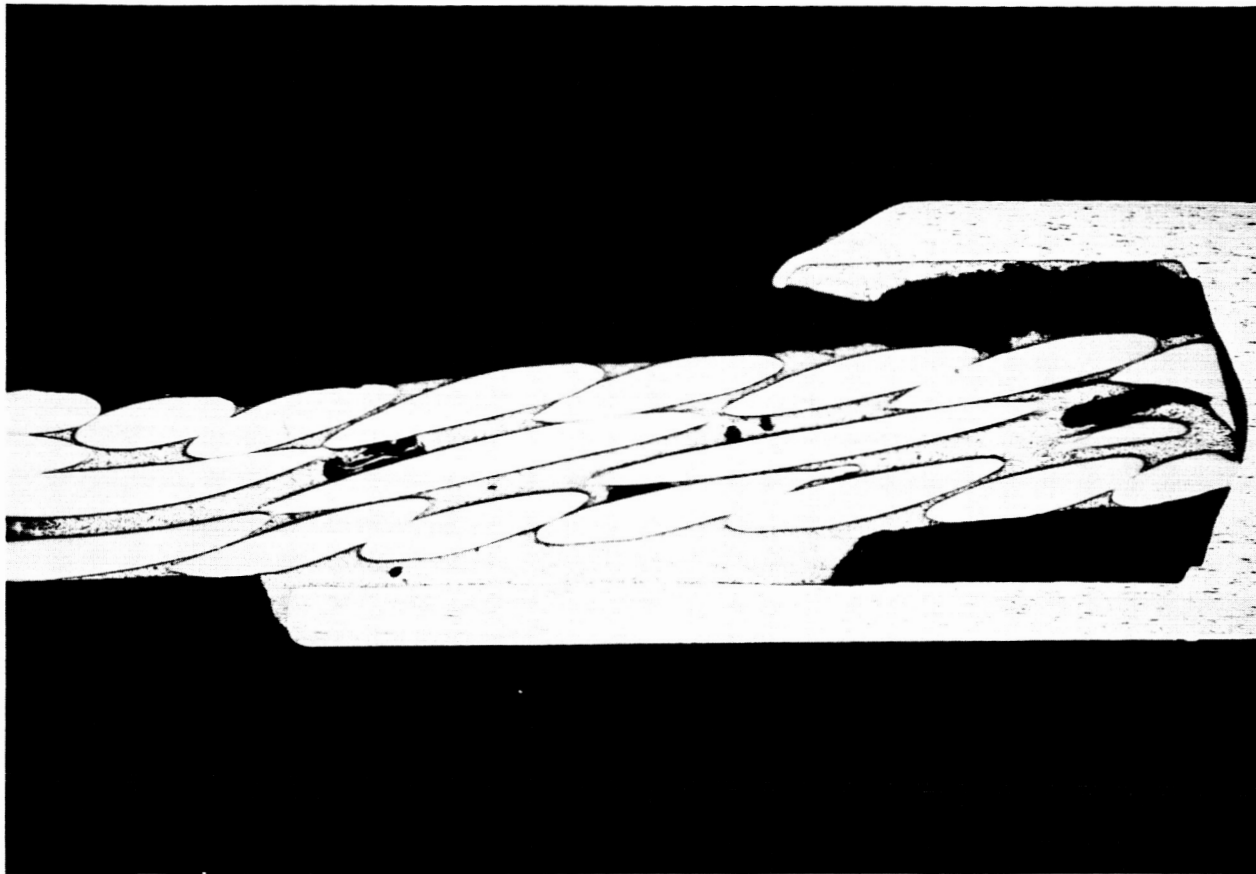
IMSC Negative No. 22935  
Magnification 33x

Transverse section through stranded wire to connector  
pin connection.

22 AWG-19 strand copper wire, silver plated, Teflon insulated, soldered into cup of #202 connector pin, using Alpha Metals 60/40 Plastic Core solder.

Note: Incomplete and irregular filling of cup with solder and poor wetting of strands.

FIGURE 8-4



IMSC Lab. No. 56192-1  
Test Series G-1

IMSC Negative No. 22920  
Magnification 33x

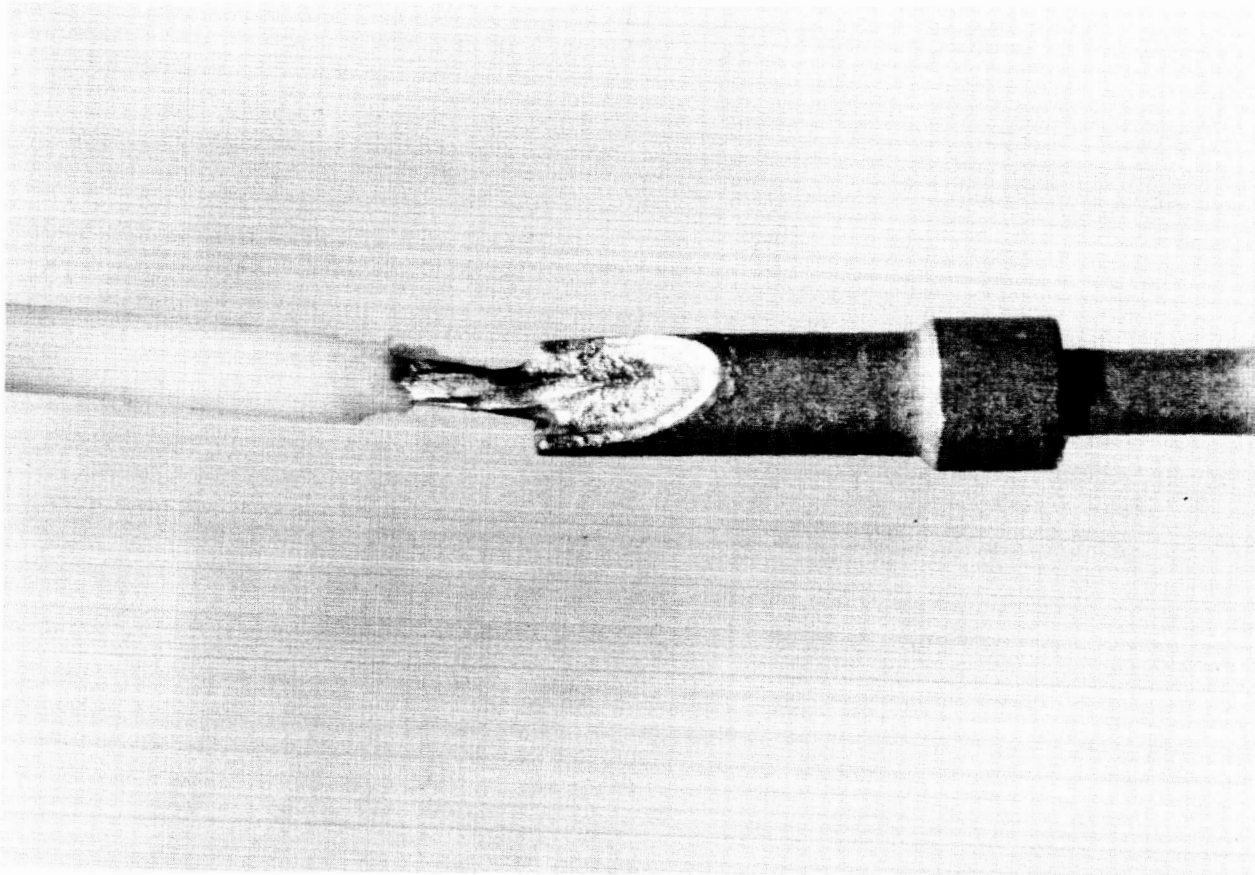
Longitudinal section through stranded wire to connector pin connection.

22 AWG-19 strand copper wire, silver plated, Teflon insulated, soldered into cup of #202 connector pin, using Alpha Metals 60/40 Plastic Core solder.

Note: Incomplete wetting of strands and cup . Large voids.

8-20

FIGURE 8-5



IMSC Lab. No. 56192-2  
Test Series No G-2

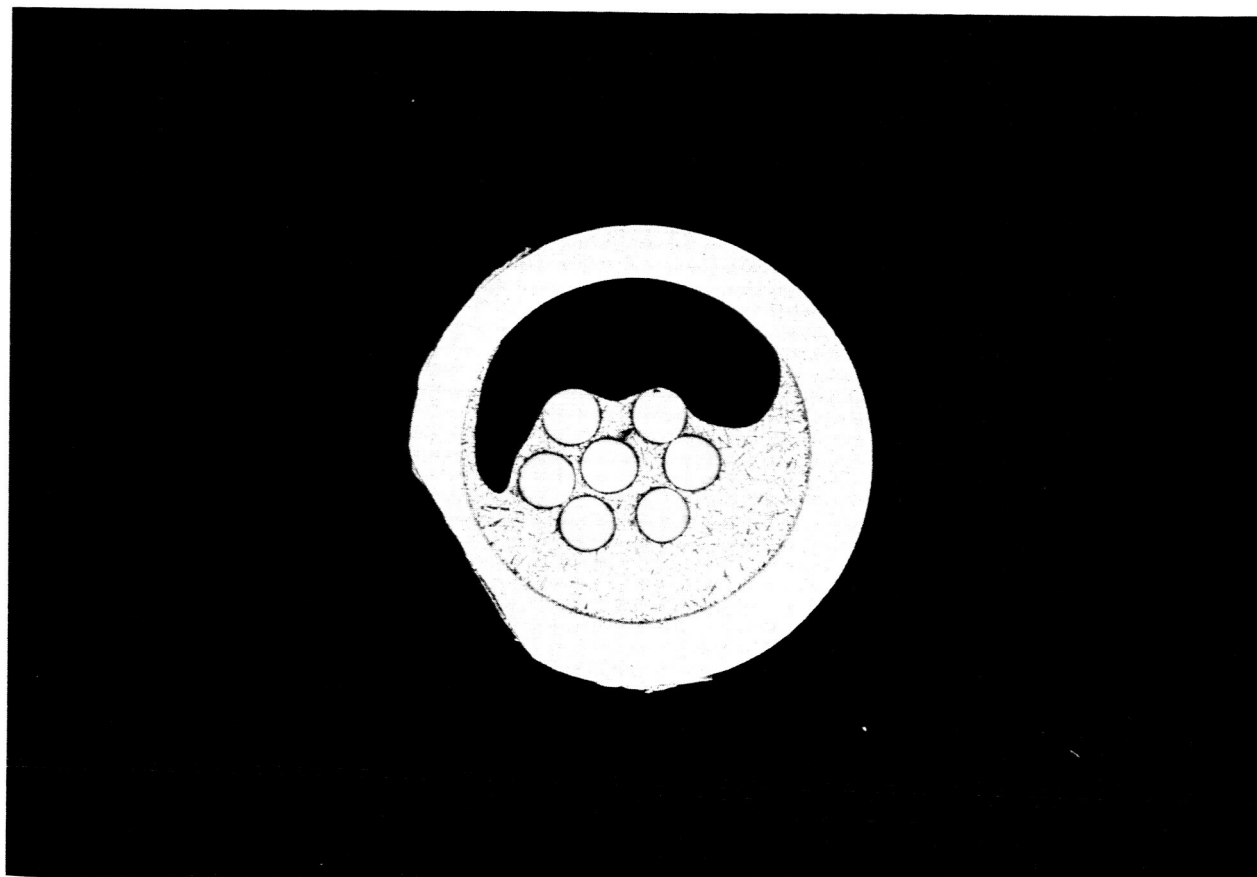
IMSC Negative No. 22849  
Magnification 9x

Enlarged view of soldered joint.

24 AWG-7 strand copper wire, silver plated, Teflon insulated, soldered into solder cup of #202 connector pin, using Alpha Metals 60/40 N.R.G. Core solder.

Note: Irregular Teflon termination shows melting area of thermal stripper.

FIGURE 8-6



IMSC Lab. No. 56192-2  
Test Series No. G-2

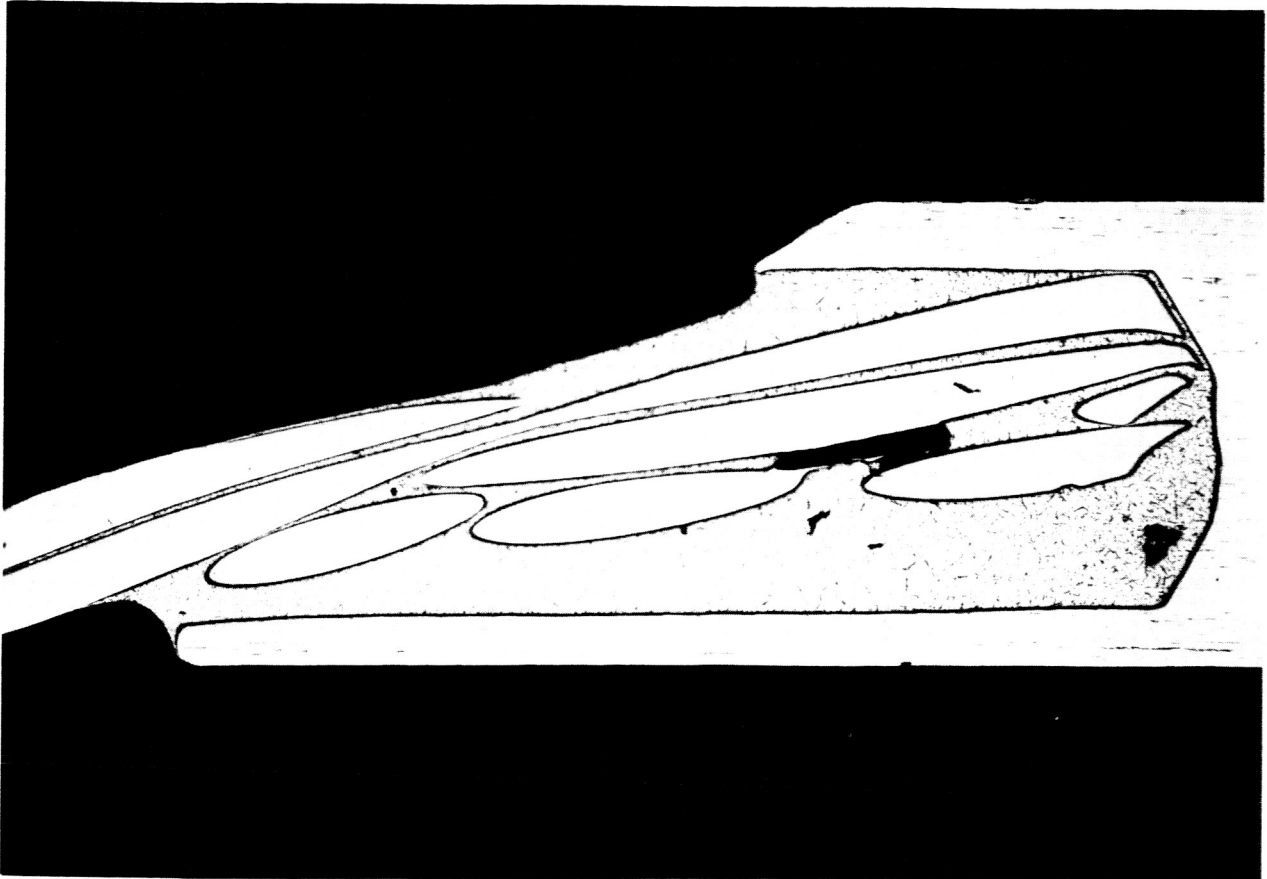
IMSC Negative No. 22936  
Magnification 33x

Transverse section through soldered joint.

24 AWG-7 strand copper wire, silver plated, Teflon insulated,  
soldered into solder cup of #202 connector pin, using Alpha  
Metals 60/40 N.R.G. Core solder.

Note: Very large void in bonding area.

FIGURE 8-7



LMSC Lab. No. 56192-2  
Test Series No. G-2

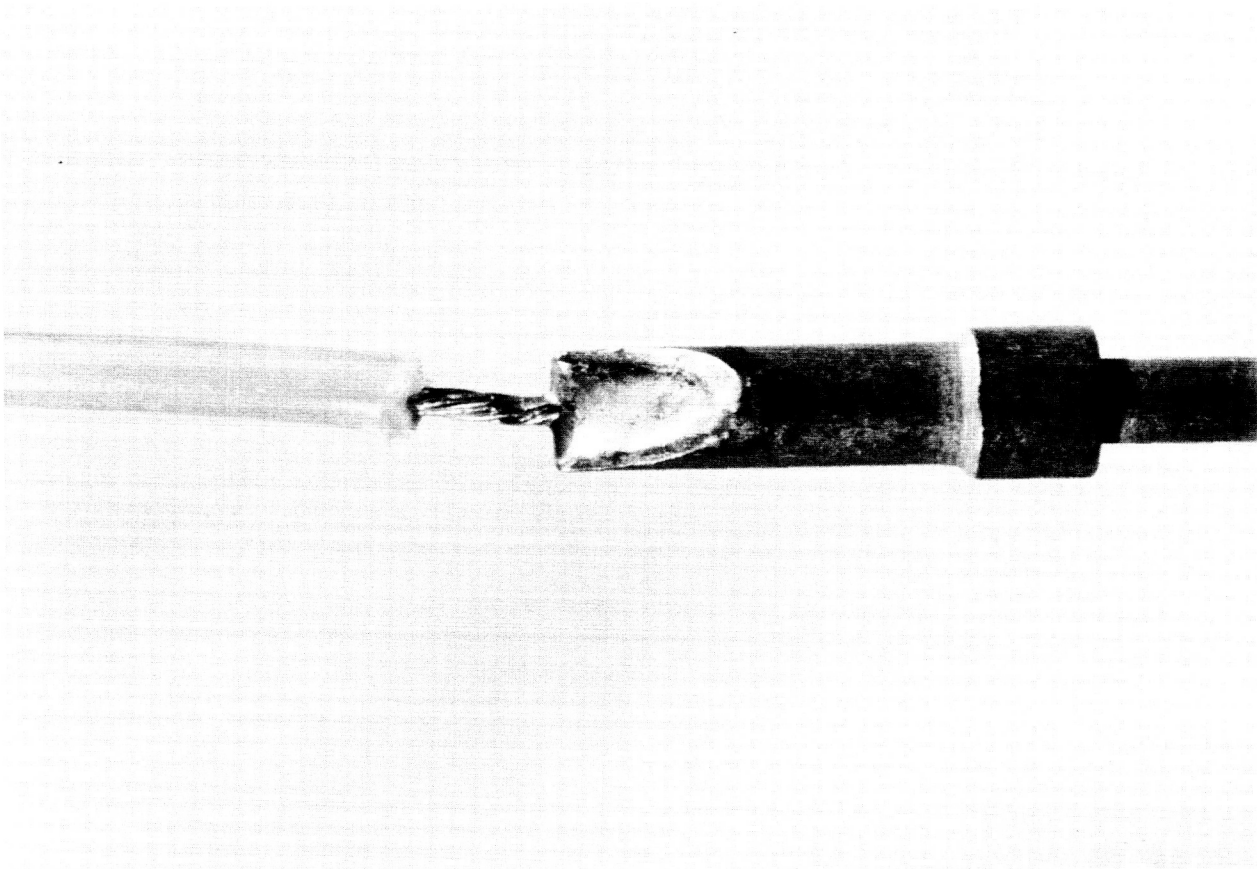
LMSC Negative No. 22922  
Magnification 33x

Transverse section through soldered joint.

24 AWG-7 strand copper wire, silver plated, Teflon insulated,  
soldered into solder cup of #202 connector pin, using Alpha  
Metals 60/40 N. R. G. Core solder.

Note: Two small voids in uncritical areas.

FIGURE 8-8



LMSC Lab. No. 56192-3  
Test Series No. G-3

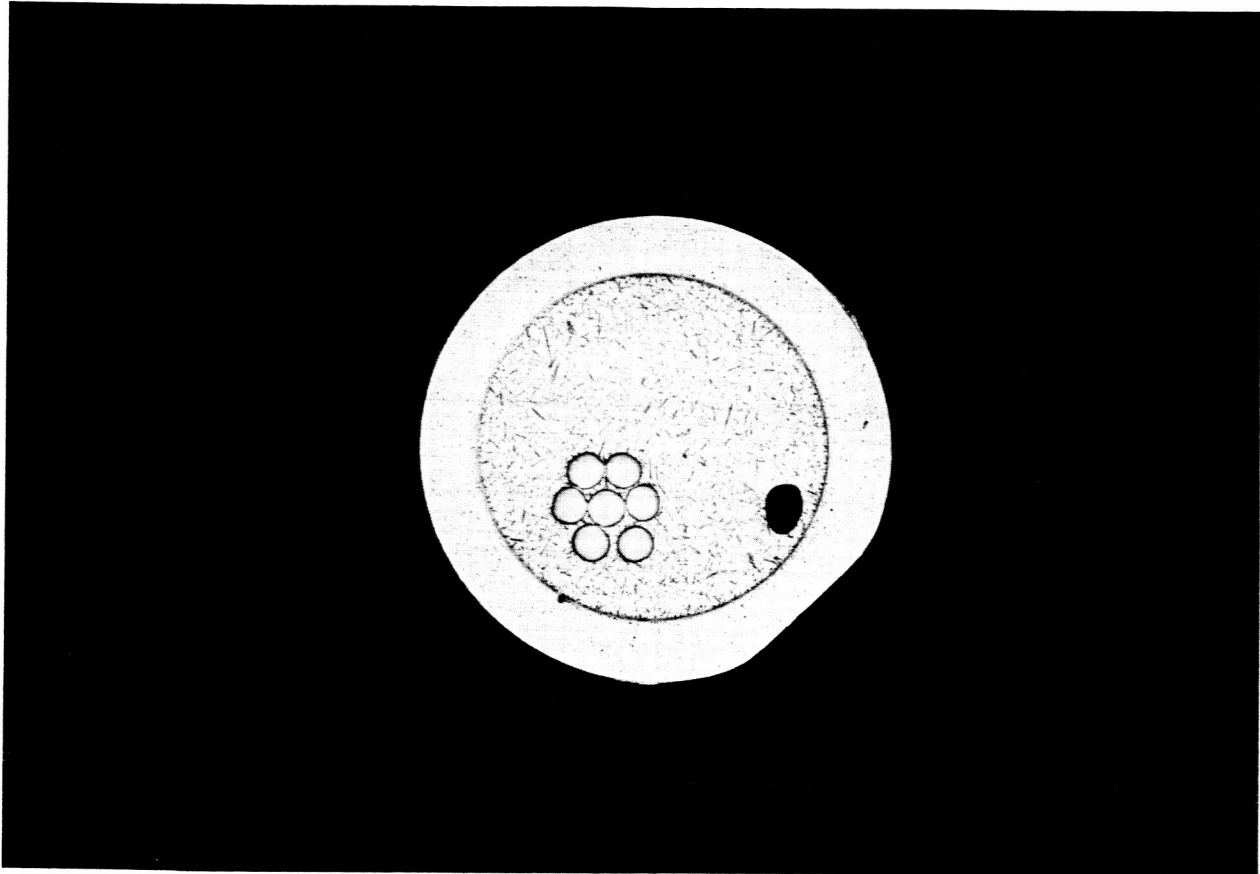
LMSC Negative No. 22850  
Magnification 9x

Enlarged view of soldered joint.

28 AWG-7 strand copper wire, solder coated, Vinyl insulated, soldered into solder cup of #202 connector pin, using Alpha Metals 60/40 N. R. G. Core solder.

Note: good insulation clearance, termination of Teflon and fillet.

FIGURE 8-9



LMSC Lab. No. 56192-3  
Test Series No. G-3

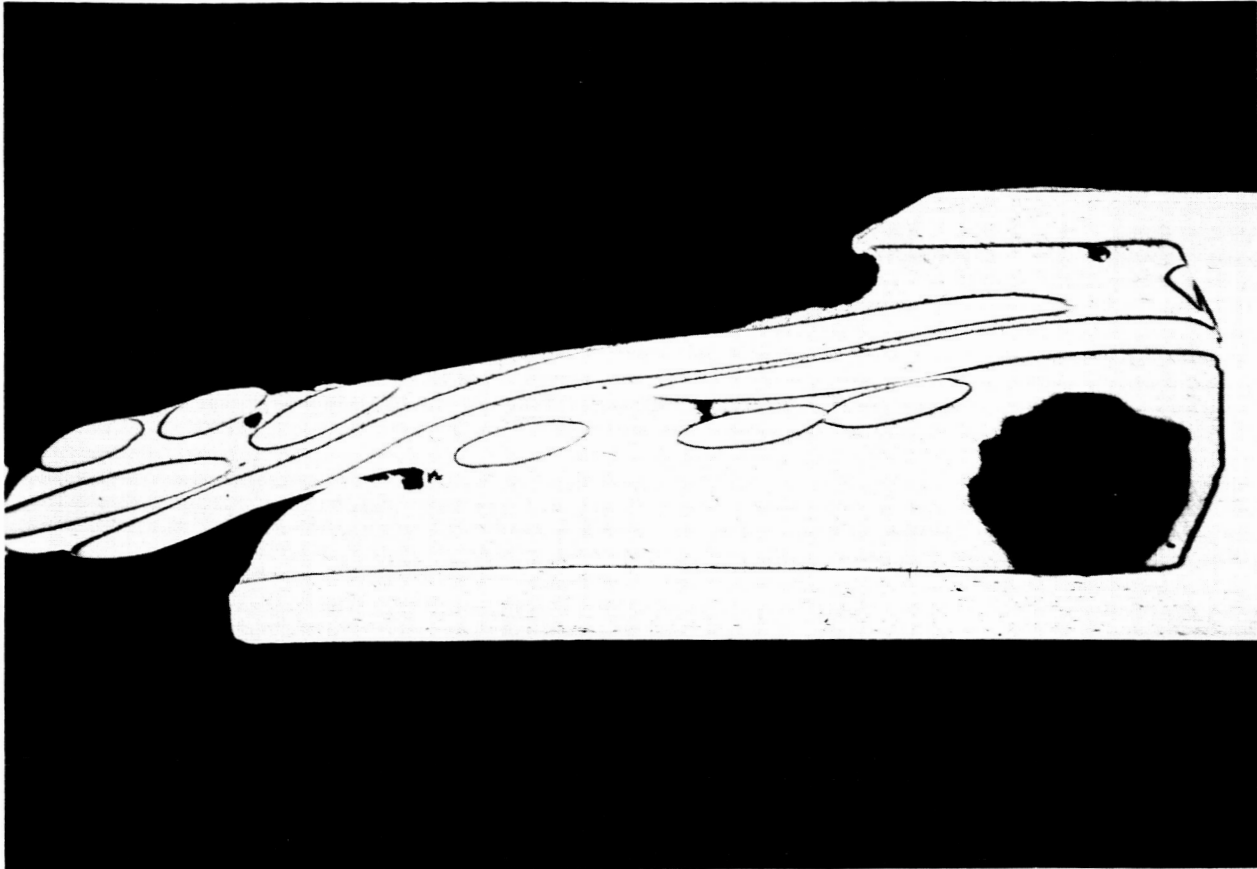
LMSC Negative No 22937  
Magnification 33x

Transverse section through soldered joint.

28 AWG-7 strand copper wire, solder coated, Vinyl insulated, soldered into solder cup of #202 connector pin, using Alpha Metals 60/40 N. R. G. Core solder.

Note: Only one small void in this solder is visible. Wetting of strands is complete.

FIGURE 8-10



IMSC Lab. No. 56192-3  
Test Series No. G-3

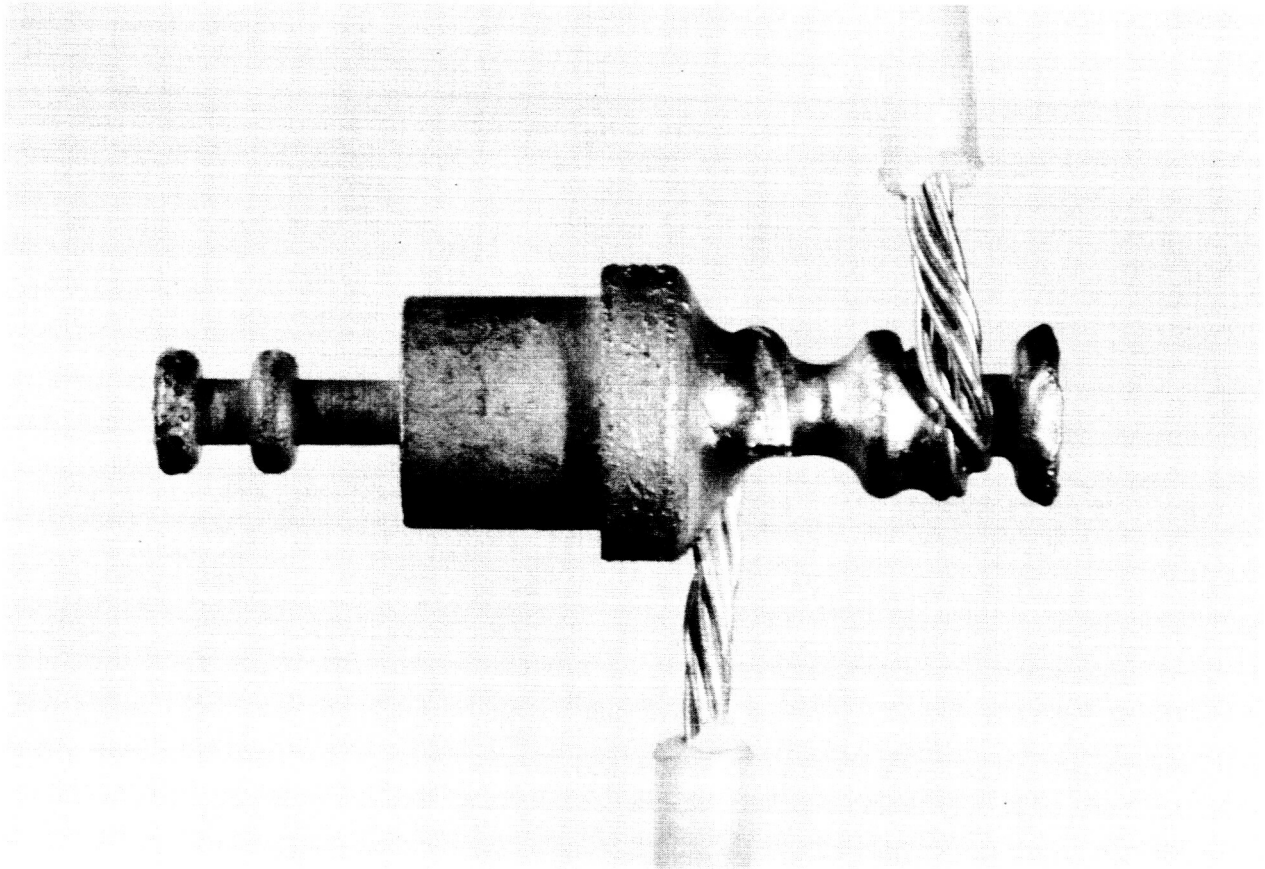
IMSC Negative No. 22921  
Magnification 33x

Longitudinal section through soldered joint.

28 AWG-7 strand copper wire, solder coated, Vinyl insulated, soldered into solder cup of #202 connector pin, using Alpha Metals 60/40 N. R. G. Core solder.

Note: Meager fillet on outside of cup and large void (air bubble) on bottom of cup.

FIGURE 8-11



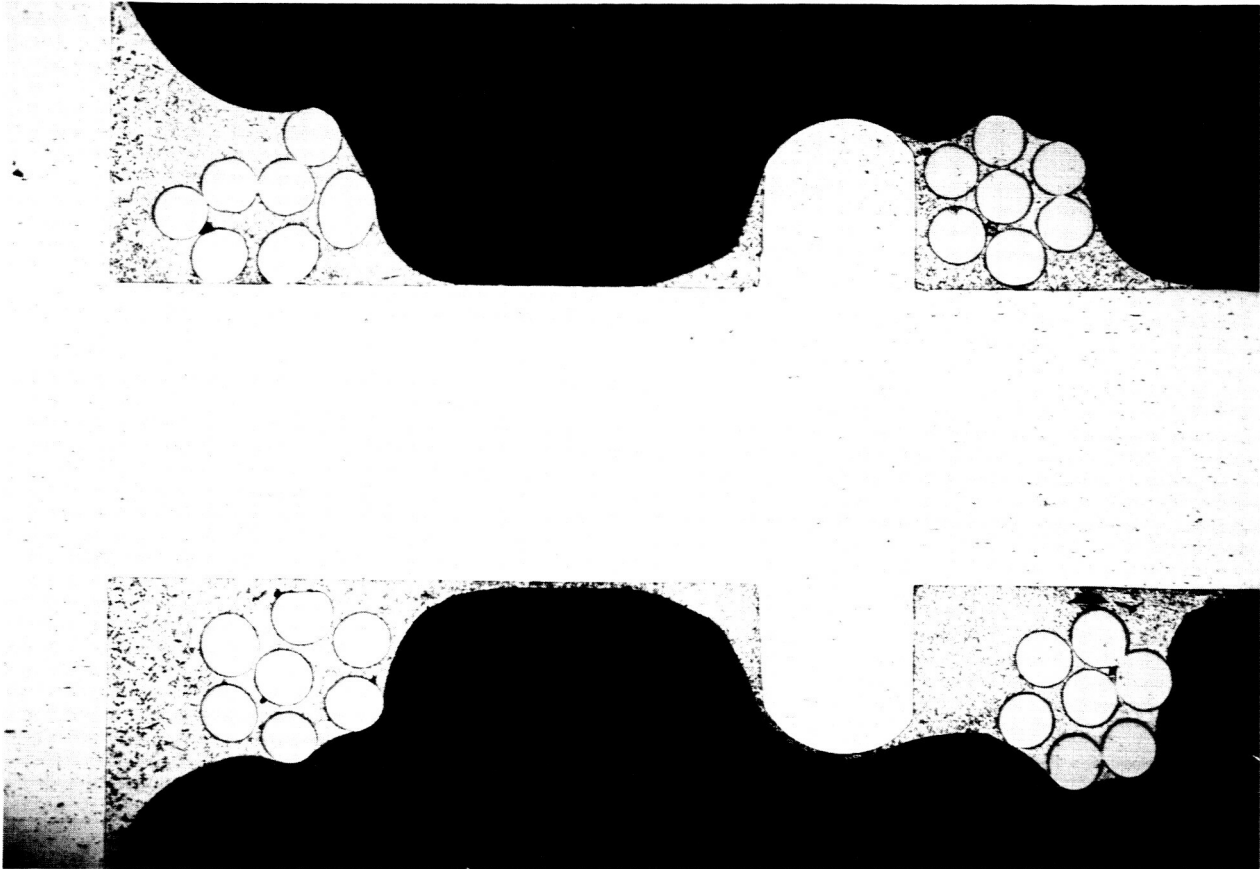
IMSC Lab. No. 56192-4  
Test Series No. G-4

IMSC Negative No. 22854  
Magnification 9x

Enlarged view of turret terminal with two wires attached.

24 AWG-7 strand copper wire, solder coated, Vinyl insulation,  
soldered around #8958-2 turret terminal, using Alpha Metals  
60/40 N. R. G. Core solder.

FIGURE 8-12



IMSC Lab. No. 56192-4  
Test Series No. G-4

IMSC Negative No. 22918  
Magnification 33x

Longitudinal section through turret terminal with wires attached.

24 AWG-7 strand copper wire, solder coated, Vinyl insulated,  
bonded to #8958-2 turret terminal, using Alpha Metals 60/40  
N. R. G. Core solder.

Note: Good fillet between wires and post.

FIGURE 8-13



IMSC Lab. No. 56192-4  
Test Series No. G-4

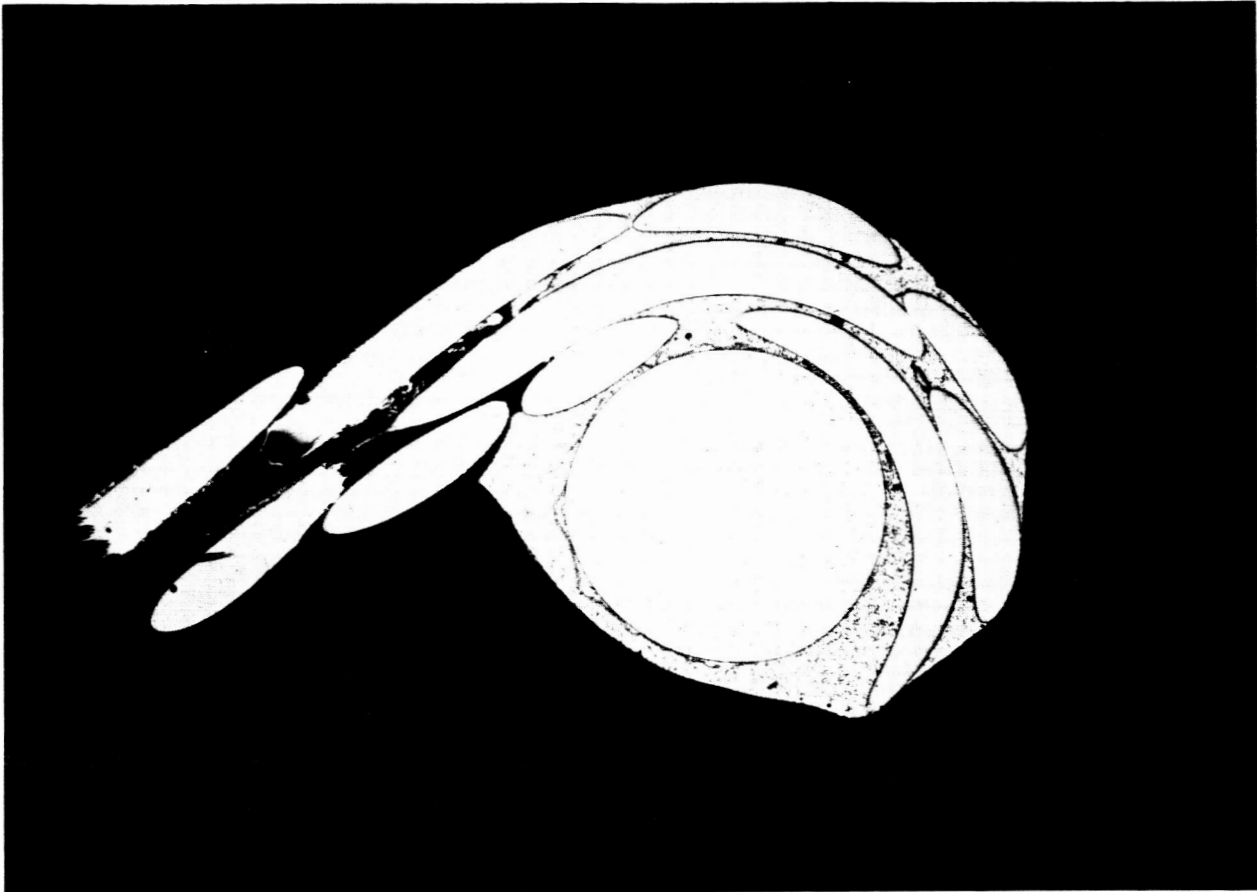
IMSC Negative No. 22940  
Magnification 33x

Transverse section through upper part of turret terminals.

24 AWG-7 strand copper wire, solder coated, Vinyl insulated,  
bonded to #8958-2 turret terminal, using Alpha Metals 60/40  
N. R. G. Core solder.

Note: Good fillet between wire and post.

FIGURE 8-14



IMSC Lab. No. 56192-4  
Test Series No. G-4

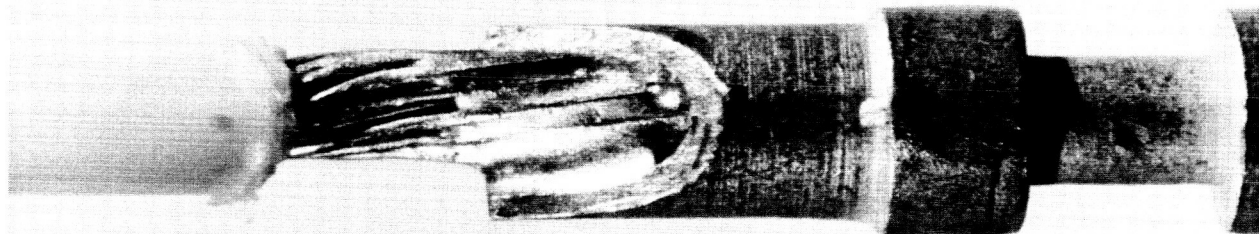
IMSC Negative No. 22941  
Magnification 33x

Transverse section through lower part of turret terminal.

24 AWG-7 strand copper wire, solder coated, Vinyl insulated,  
bonded to #8958-2 turret terminal, using Alpha Metals 60/40  
N. R. G. Core solder.

Note: Good fillet between wire and post.

FIGURE 8-15



IMSC Lab. No. 56192-5  
Test Series No. G-5

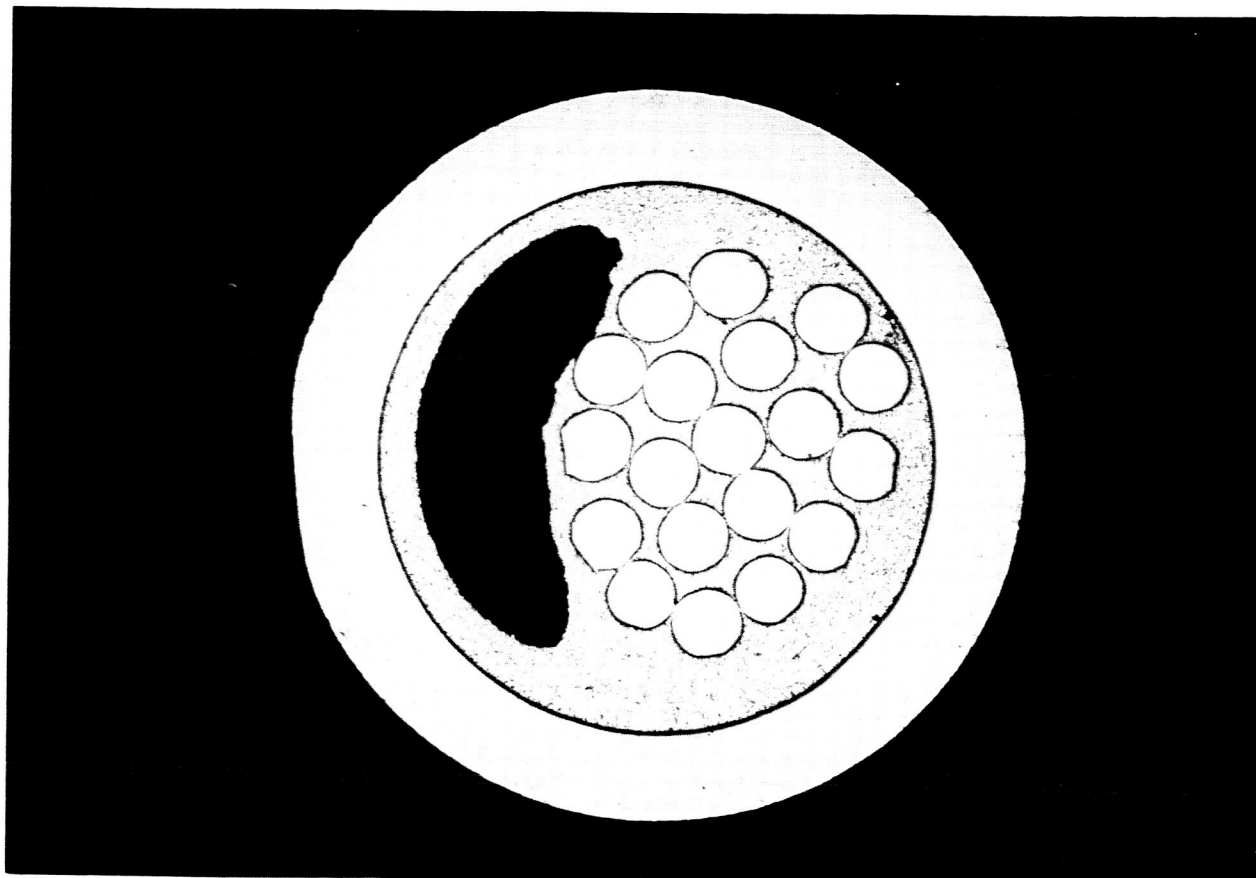
IMSC Negative No. 22851  
Magnification 9x

Enlarged view of joint.

18 AWG-19 strand copper wire, solder coated, Vinyl insulated,  
solder into solder cup of #162 connector pin, using Alpha Metals  
60/40 Plastic Core solder.

Note: Incomplete fillet.  
8-31

FIGURE 8-16



IMSC Lab. No. 56192-5  
Test Series No. G-5

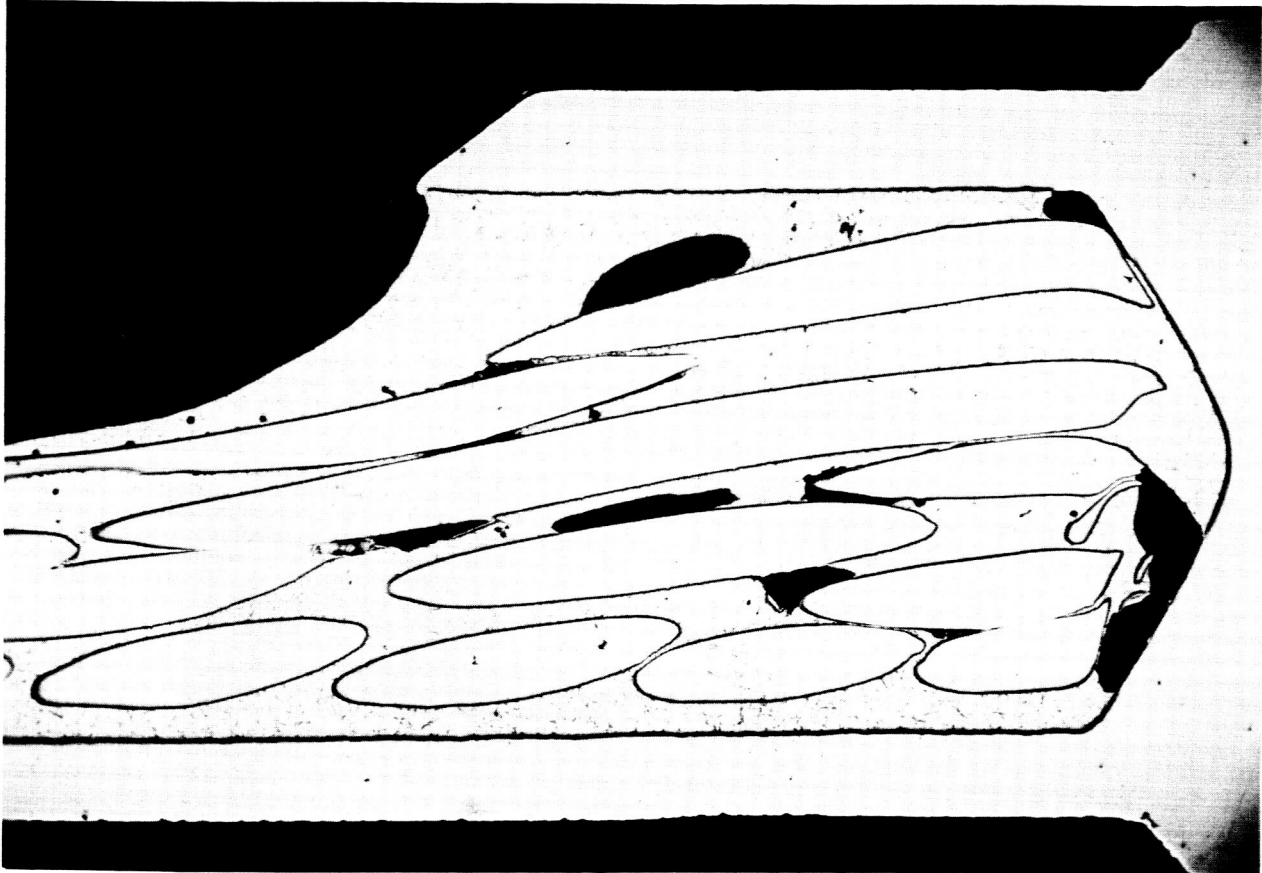
IMSC Negative No. 22938  
Magnification 33x

Transverse section through solder cup.

18 AWG-19 strand copper wire, solder coated, Vinyl insulated,  
soldered into solder cup of #162 connector pin, using Alpha  
Metals 60/40 Plastic Core solder.

Note: Air bubble void, wetting good.

FIGURE 8-17



IMSC Lab. No. 56192-5  
Test Series No. G-5

IMSC Negative No. 22923  
Magnification 33x

Longitudinal section through solder cup.

18 AWG-19 strand copper wire, solder coated, Vinyl insulated,  
soldered into solder cup of #162 connector pin, using Alpha  
Metals 60/40 Plastic Core solder.

Note: Several small voids between wires.

FIGURE 8-18



IMSC Lab. No. 56192-6  
Test Series No. G-6

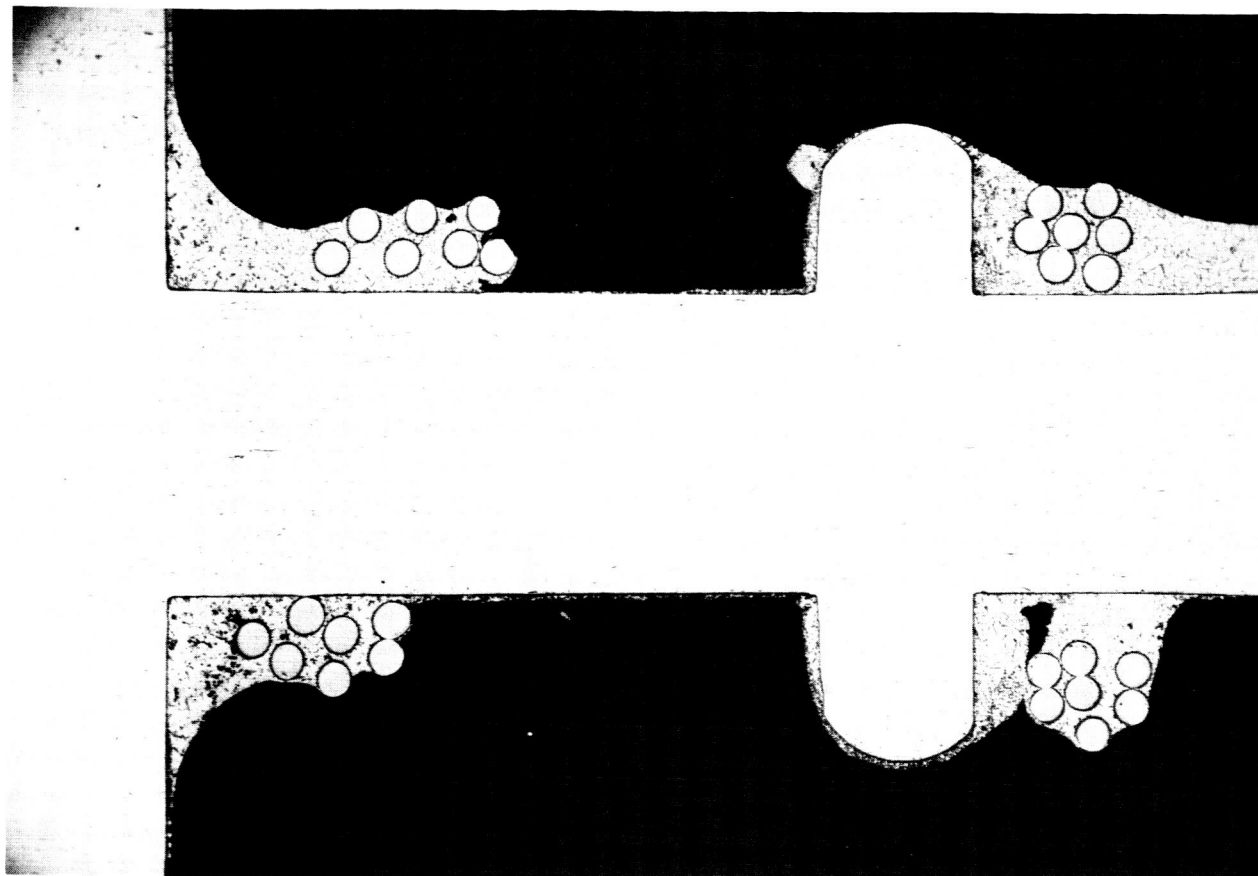
IMSC Negative No. 22853  
Magnification 9x

Enlarged view of turret terminal with two soldered joints.

28 AWG-7 strand copper wire, silver plated, Teflon insulated,  
bonded to #8958-2 turret terminal, using Alpha Metals 60/40  
Plastic Core solder.

Note: Wetting and embedment of wires insufficient.

FIGURE 8-19



IMSC Lab. No. 56192-6  
Test Series No. G-6

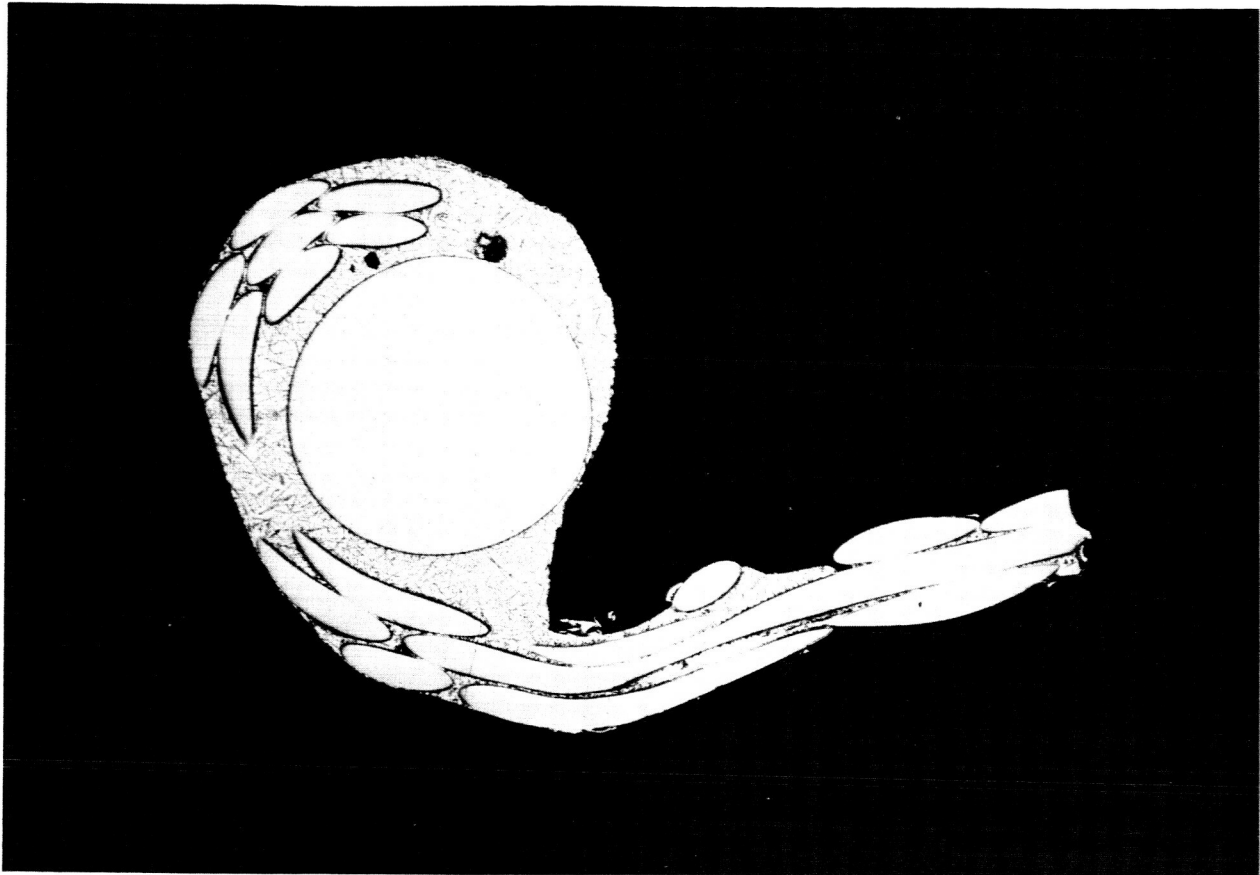
IMSC Negative No. 22919  
Magnification 33x

Longitudinal section through turret terminals.

28 AWG-7 strand copper wire, silver plated, Teflon insulated, soldered to turret terminal #8958-2, using Alpha Metals 60/40 Plastic core solder.

Note: Insufficient fillet and bare wire surfaces.

FIGURE 8-20



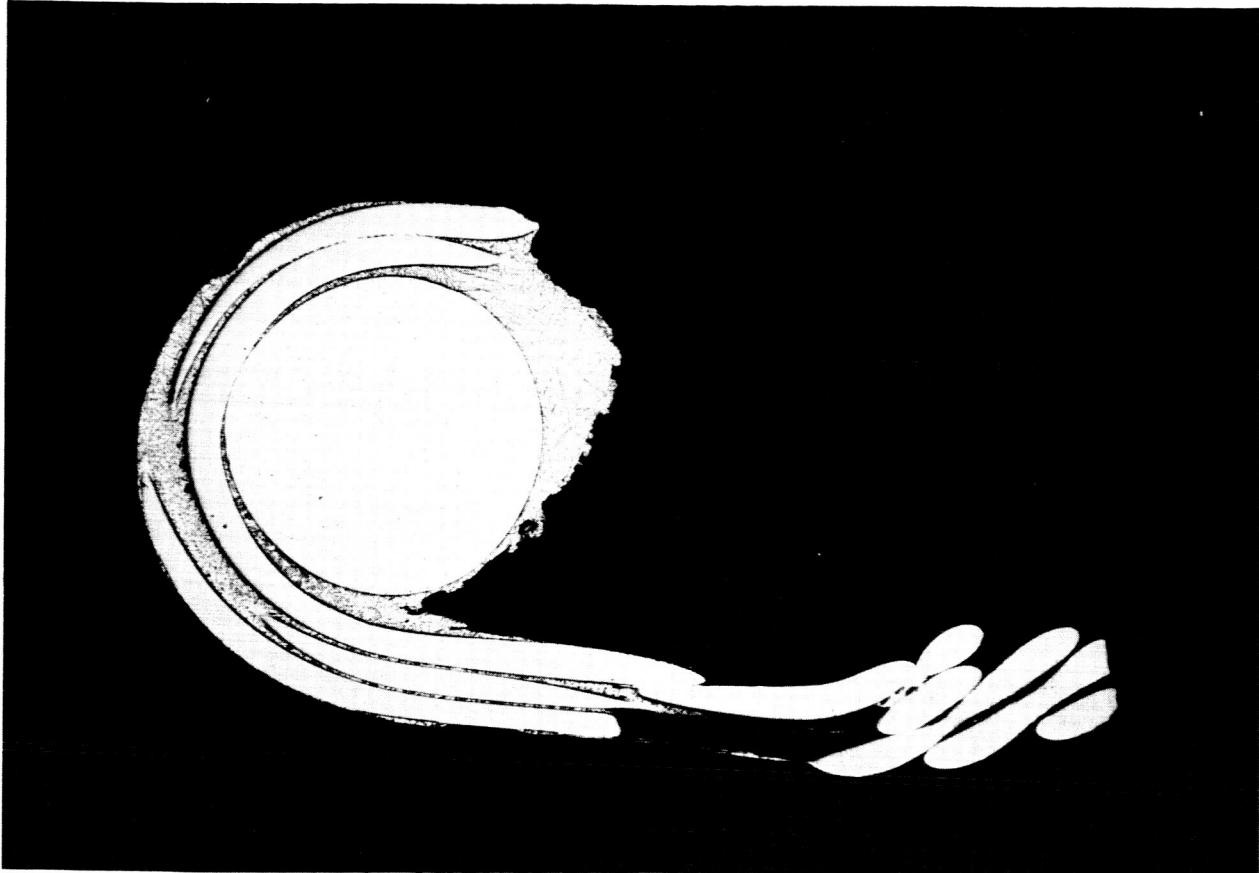
LMSC Lab. No. 56192-6  
Test Series No. G-6

LMSC Negative No. 22942  
Magnification 33x

Transverse section through turret in plane of upper connection.

28 AWG-7 strand copper wire, silver plated, Teflon insulated,  
soldered to #8958-2 turret terminal, using Alpha Metals 60/40  
Plastic Core solder.

FIGURE 8-21



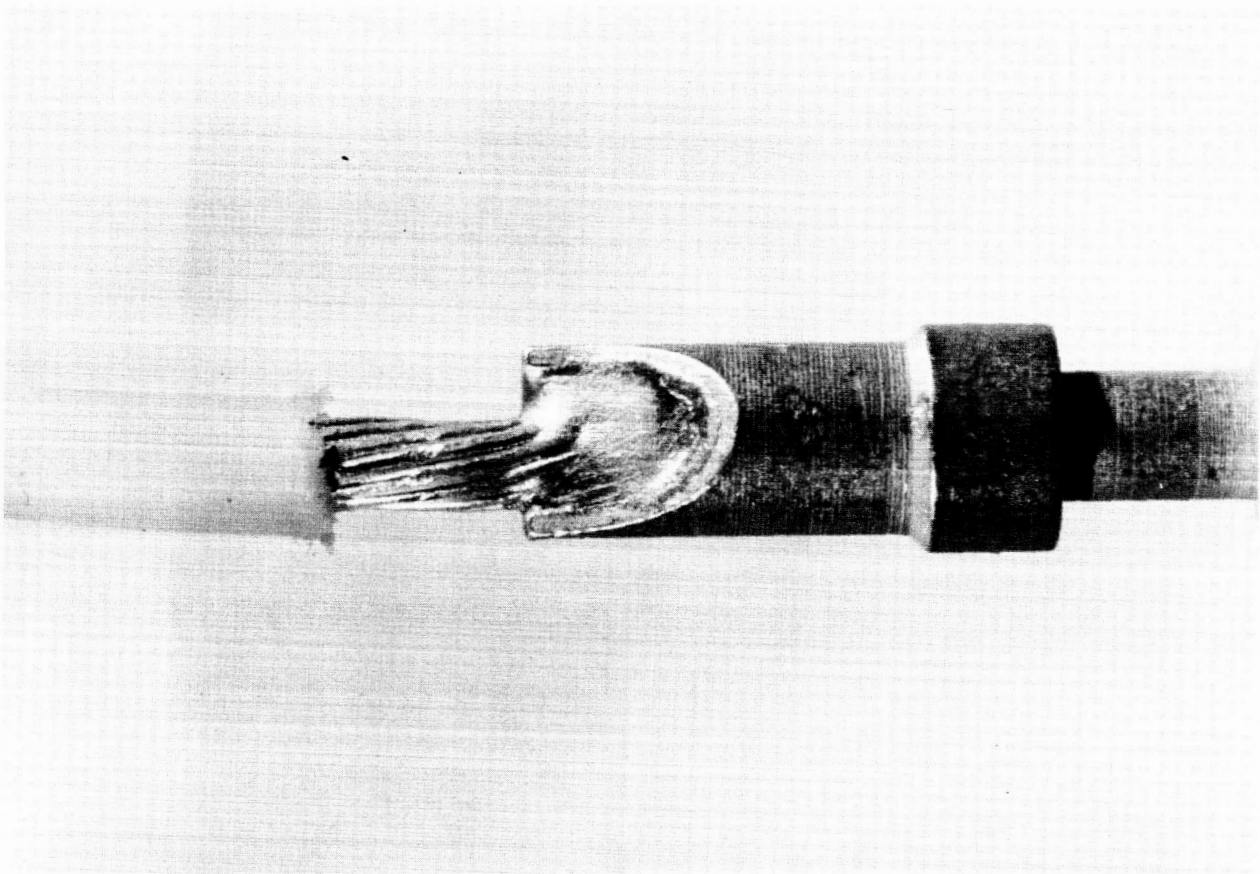
IMSC Lab. No. 56192-6  
Test Series No. G-6

IMSC Negative No. 22943  
Magnification 33x

Transverse section through turret in plane of lower connection.

28 AWG-7 strand copper wire, silver plated, Teflon insulated,  
soldered to #8958-2 turret terminal, using Alpha Metals 60/40  
Plastic Core.

FIGURE 8-22



IMSC Lab. No. 56192-7  
Test Series No. G-7

Negative No. 22852  
Magnification 9x

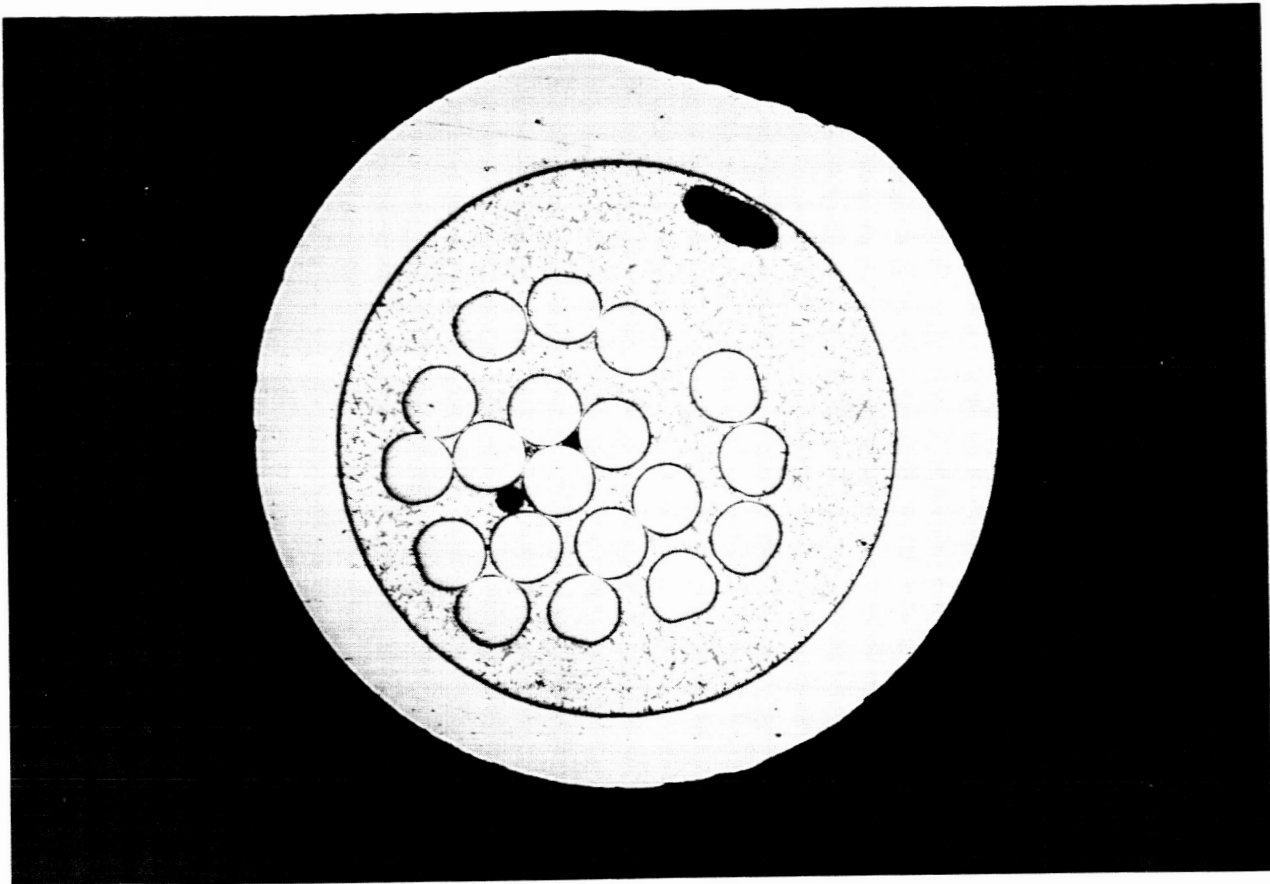
Enlarged view of one joint.

18 AWG-19 strand wire, silver plated, Teflon insulated,  
soldered into solder cup of #162 turret terminal, using  
Alpha Metals 60/40 N. R. G. Core solder.

Note: Fillet insufficient, and Teflon termination is  
slightly irregular.

8-38

FIGURE 8-23



IMSC Lab. No. 56192-7  
Test Series No. G-7

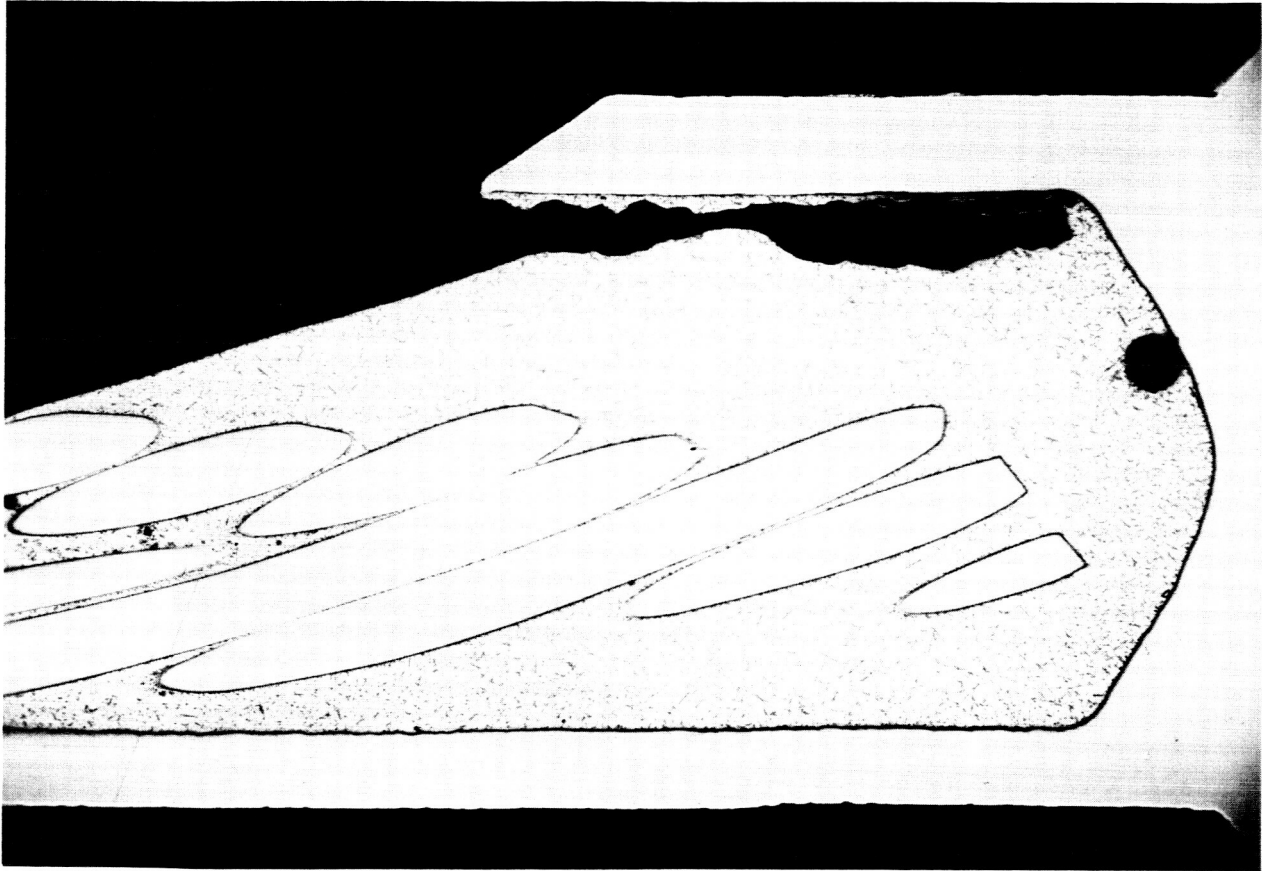
IMSC Negative No 22939  
Magnification 33x

Transverse section through soldered joint.

18 AWG-19 strand wire, silver plated, Teflon insulation, soldered into solder cup of #162 turret terminal, using Alpha Metals 60/40 N. R. G. Core solder.

Note: good wetting but two voids visible.

FIGURE 8-24



IMSC Lab. No. 56192-7  
Test Series No. G-7

IMSC Negative No. 22924  
Magnification 33x

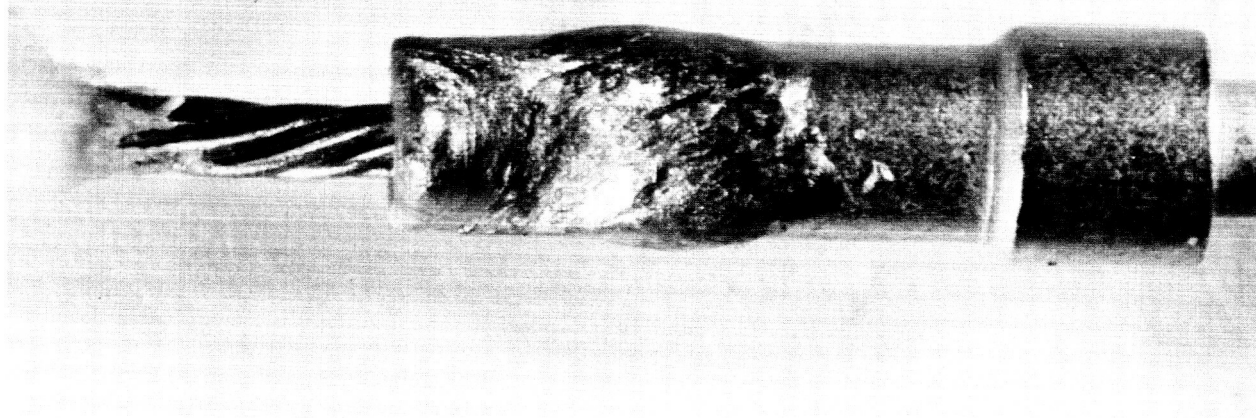
Longitudinal section through soldered joint.

18 AWG-19 strand wire, silver plated, Teflon insulated,  
soldered into solder cup of #162 turret terminal, using  
Alpha Metals 60/40 N. R. G. Core solder.

Note: Small void on bottom and hollow channel on side of  
solder cup.

8-40

FIGURE 8-25



IMSC Lab. No. 58573  
Test Series No. G-8

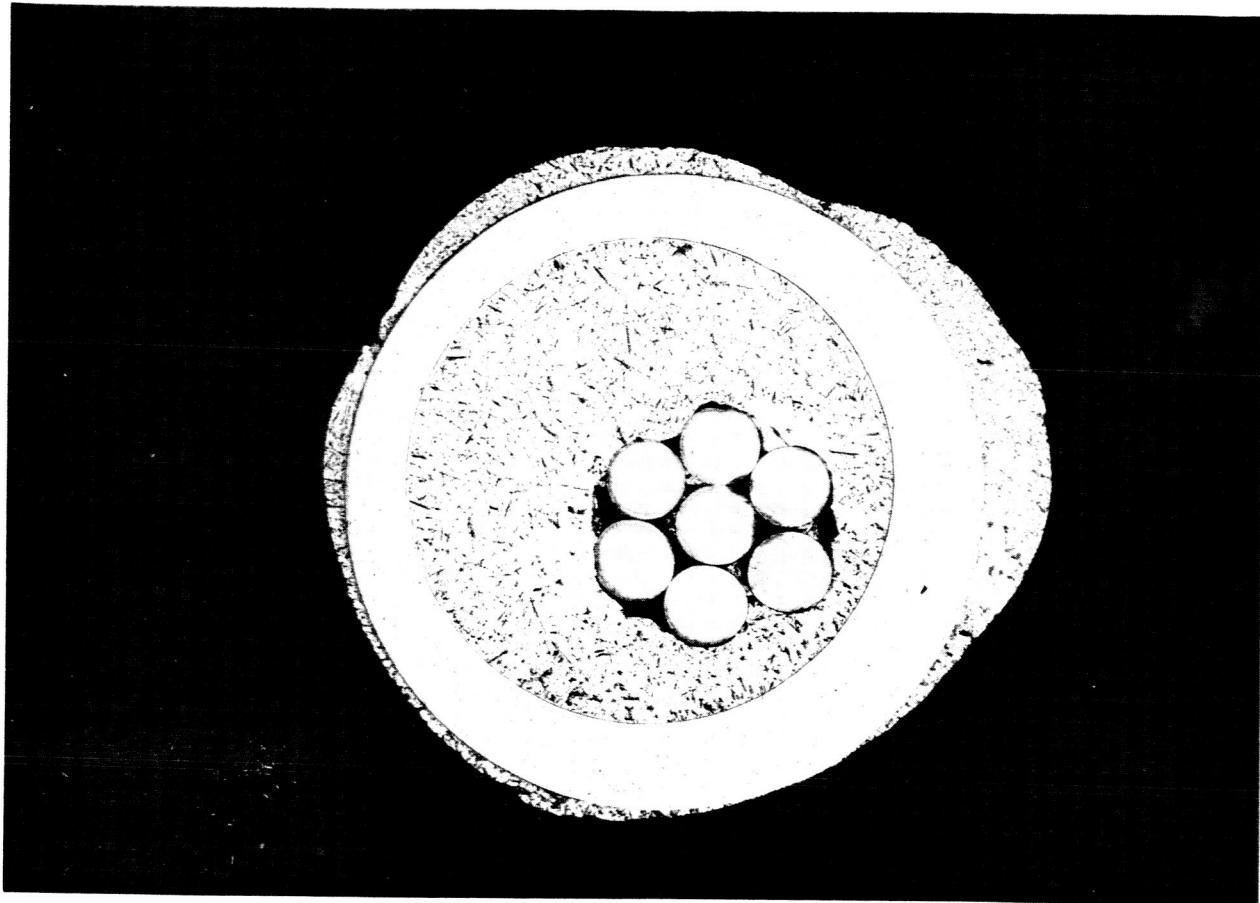
IMSC Negative No. 24735  
Magnification 15x

Enlarged view of typical joint.

24 AWG-7 strand wire, nickel plated, Teflon insulated,  
soldered into solder cup of #202 connector pin, using  
Alpha Metals 60/40 Plastic Core solder.

Note: Incomplete wetting and "cold-joint" - like surface.

FIGURE 8-26



IMSC Lab. No. 58573  
Test Series No. G-8

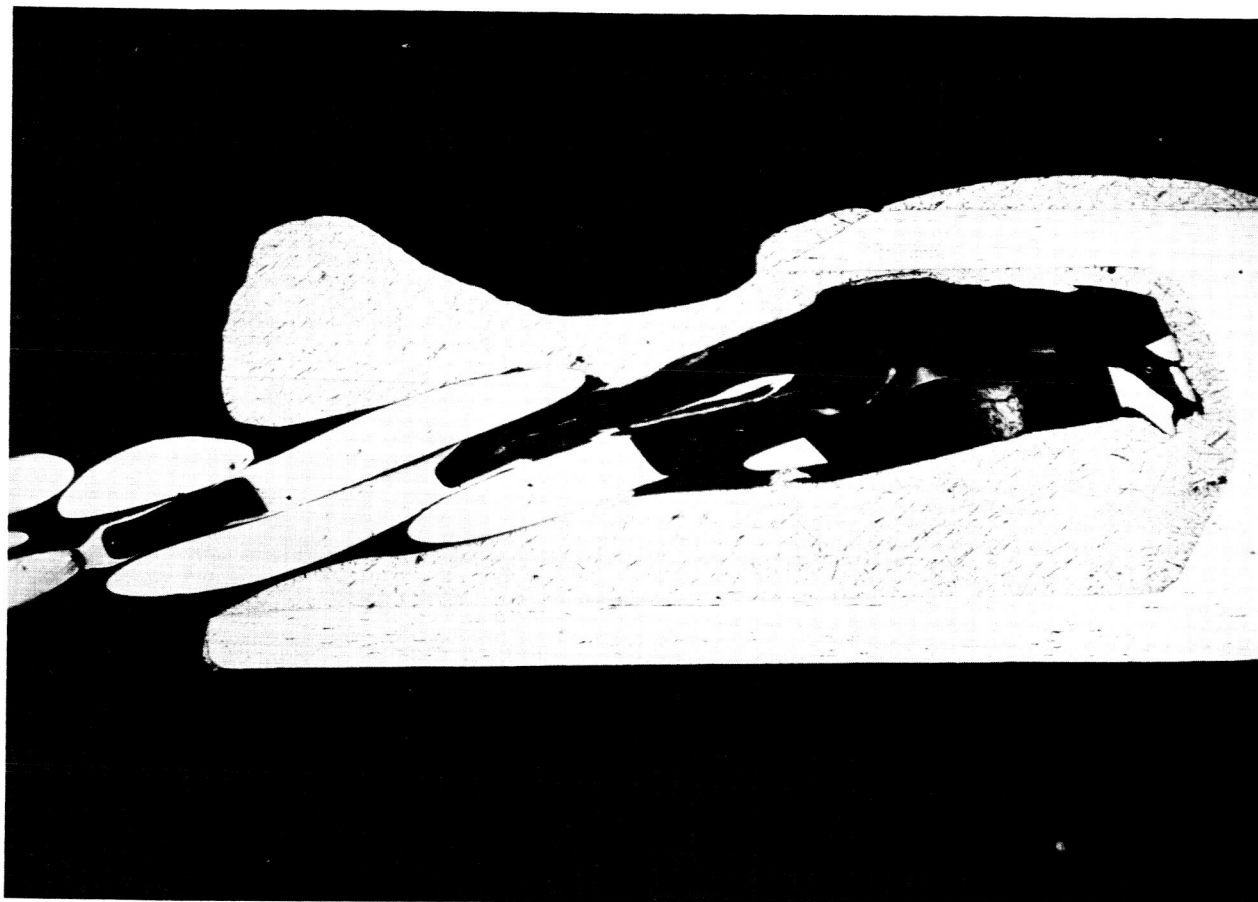
IMSC Negative No. 24802  
Magnification 50x

Transverse section through soldered joint.

24 AWG-7 strand wire, nickel plated, Teflon insulated,  
soldered into solder cup of #202 connector pin, using  
Alpha Metals 60/40 Plastic Core solder.

Note: Incomplete wetting of nickel plated wire due to  
use of non-activated flux.

FIGURE 8-27



LMSC Lab. No. 58573  
Test Series No. G-8

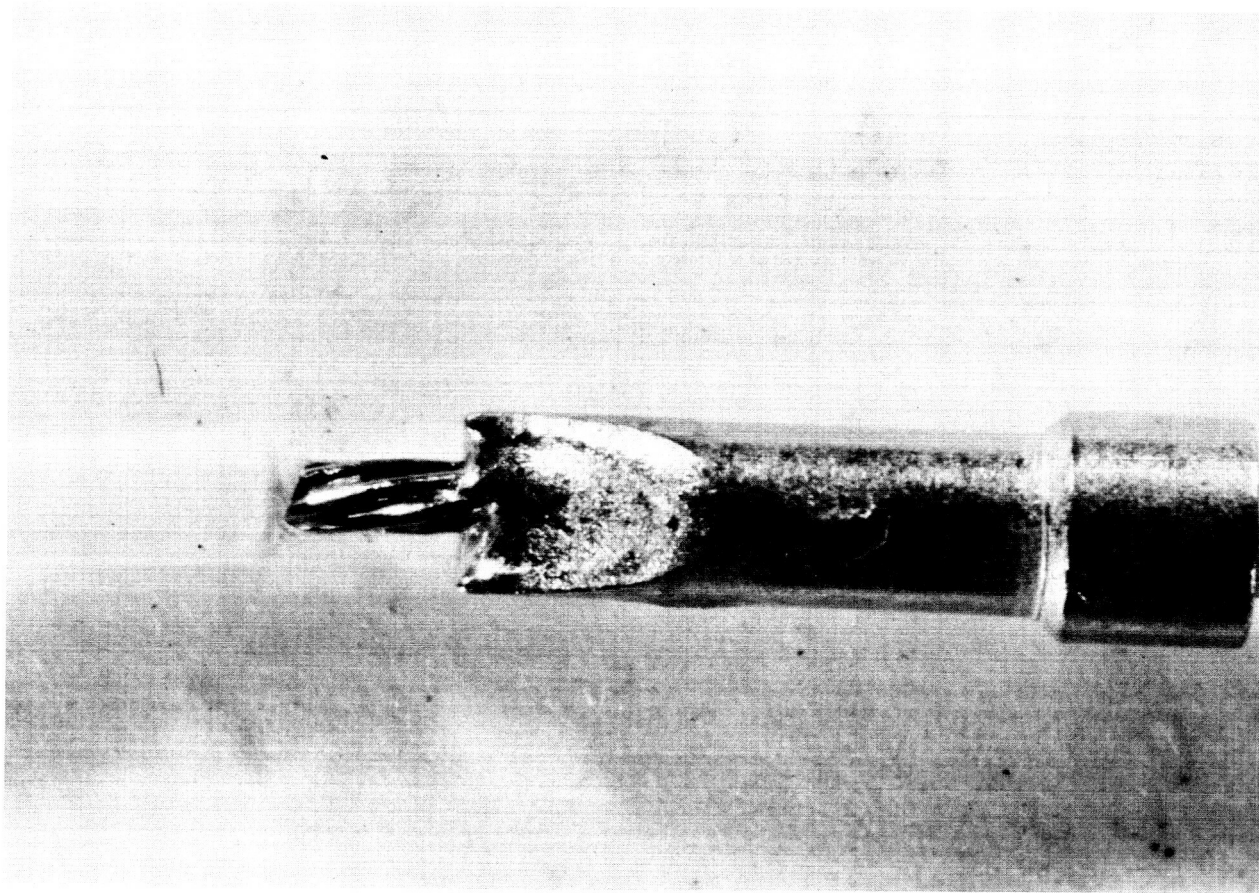
LMSC Negative No. 24807  
Magnification 35x

Longitudinal section through soldered joint.

24 AWG-7 strand wire, nickel plated, Teflon insulated, soldered into solder cup of #202 connector pin, using Alpha Metals 60/40 Plastic Core solder.

Note: Incomplete wetting of nickel plated wire due to use of non-activated flux.

FIGURE 8-28



LMSC Lab. No. 58573  
Test Series No. G-9

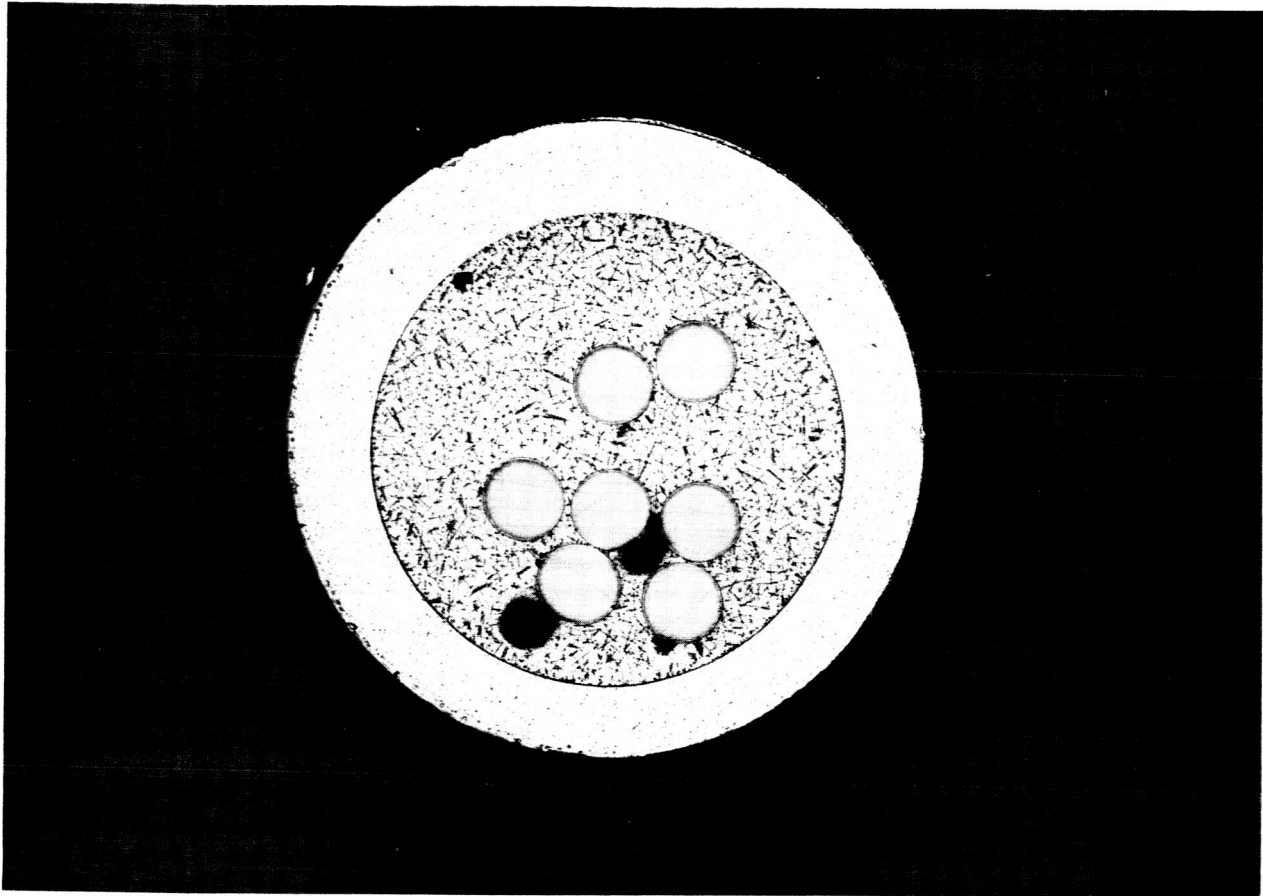
LMSC Negative No. 24736  
Magnification 15x

Enlarged view of soldered joint.

24 AWG-7 stranded wire, nickel plated, Teflon insulated,  
soldered into solder cup of #202 connector pin, using Alpha  
Metals 60/40 N. R. G. Core solder.

Note: Teflon termination still uneven, but slightly improved.

FIGURE 8-29



IMSC Lab. No. 58573  
Test Series No. G-9

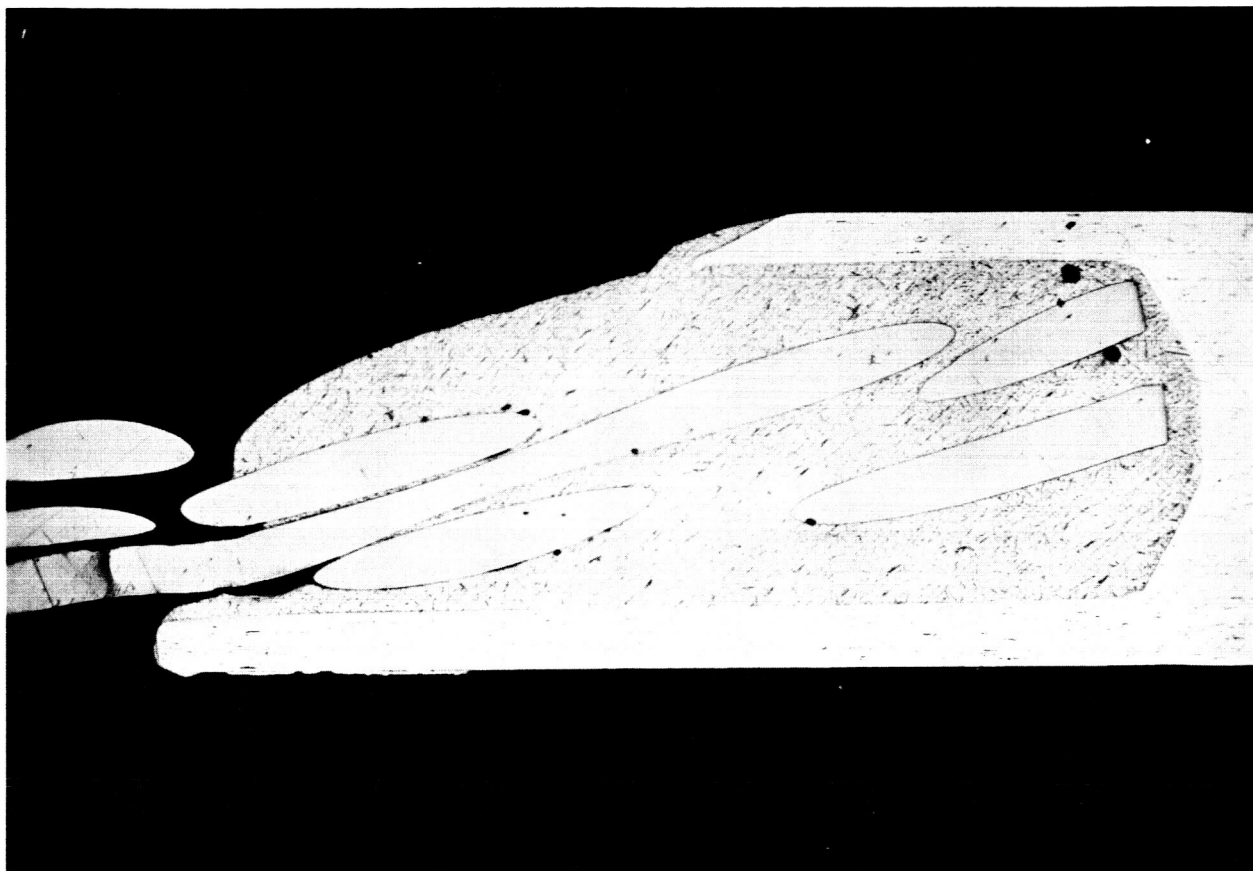
IMSC Negative No. 24803  
Magnification 50x

Transverse section of joint.

24 AWG-7 strand wire, nickel plated, Teflon insulated,  
soldered into solder cup of #202 connector pin, using  
Alpha Metals 60/40 N. R. G. Core solder.

Note: Presence of four small voids.

FIGURE 8-30



IMSC Lab. No. 58573  
Test Series No. G-9

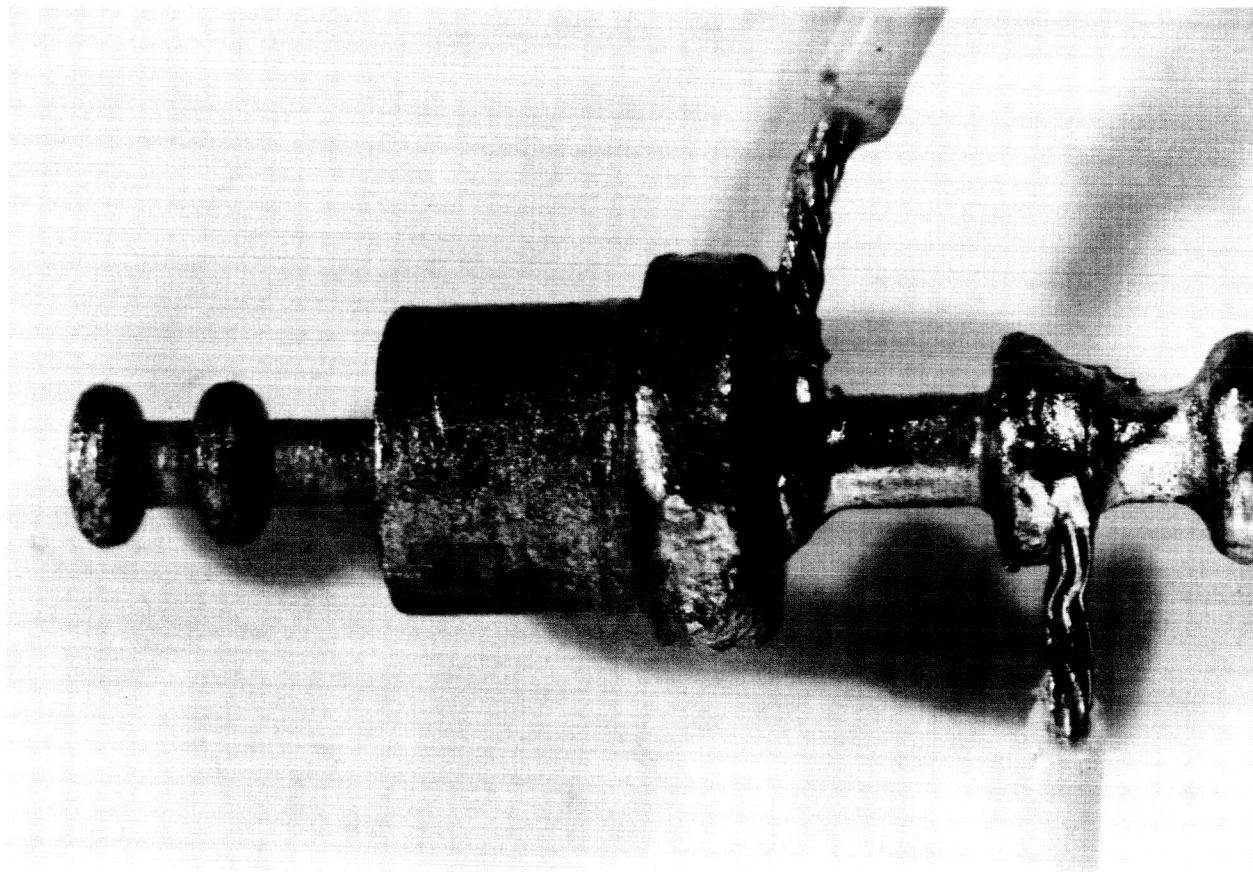
IMSC Negative No. 24808  
Magnification 35x

Longitudinal section of joint between stranded wire and solder cup.

24 AWG-7 strand wire, nickel plated, Teflon insulated, soldered into cup of #202 connector pin, using Alpha Metals 60/40 N. R. G. Core solder.

Note: Almost complete absence of voids in solder.

FIGURE 8-31



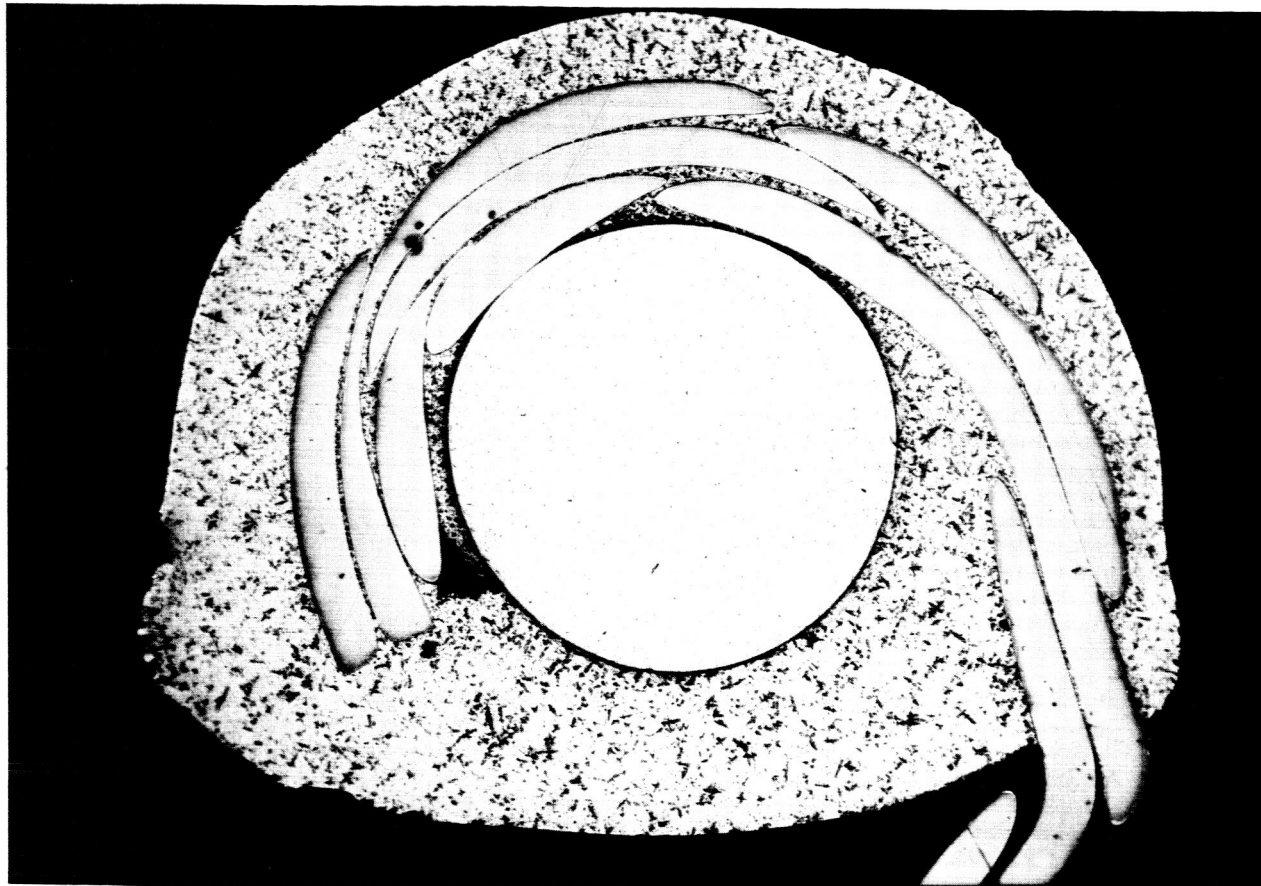
LMSC Lab. No. 58573  
Test Series No. G-10

LMSC Negative No. 24737  
Magnification 13x

Enlarged view of turret terminal with two connections.

28 AWG-7 strand wire, nickel plated, Teflon insulation,  
bonded to #8958-2 turret terminal, using Alpha Metals  
60/40 N. R. G. Core solder.

FIGURE 8-32



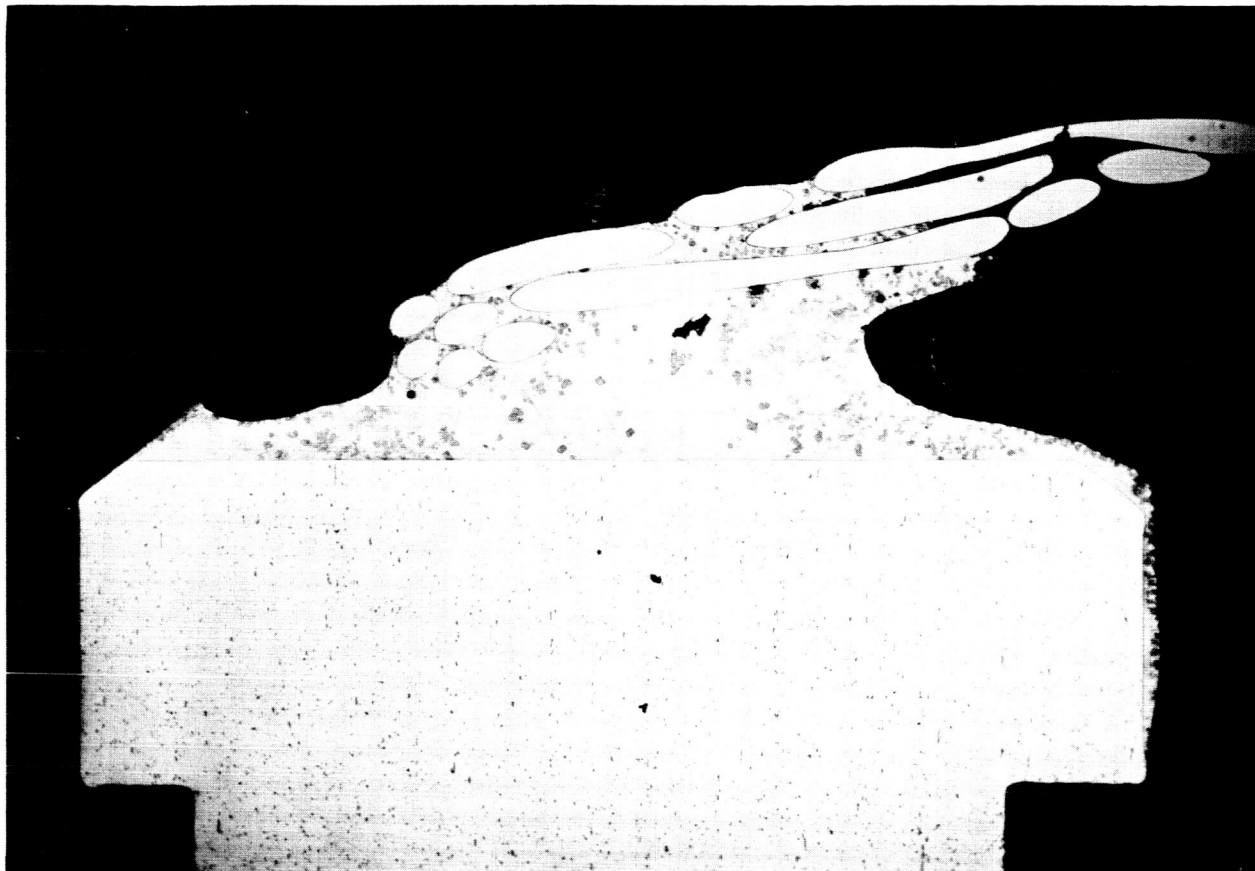
LMSC Lab. No. 58573  
Test Series No. G-10

LMSC Negative No. 24805  
Magnification 50x

Transverse section through lower joint.

28 AWG-7 strand wire, nickel plated, Teflon insulated,  
bonded to #8958-2 turret terminal, using Alpha Metals  
60/40 N. R. G. Core solder.

FIGURE 8-33



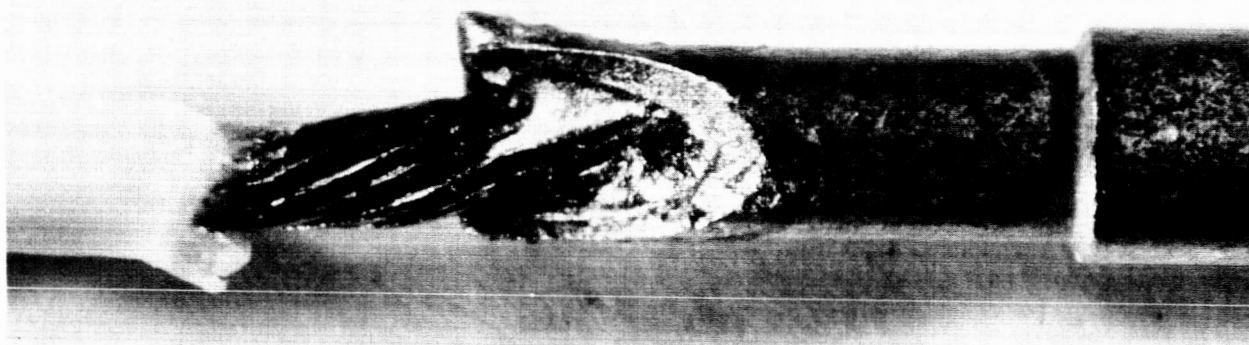
IMSC Lab. No. 58573  
Test Series G-10

IMSC Negative No. 24806  
Magnification 35x

Longitudinal section through lower joint.

28 AWG-7 strand, nickel plated, Teflon insulation, bonded  
to #8958-2 turret terminal, using Alpha Metals 60/40  
N. R. G. Core solder.

FIGURE 8-34



IMSC Lab. No. 58573  
Test Series G-11

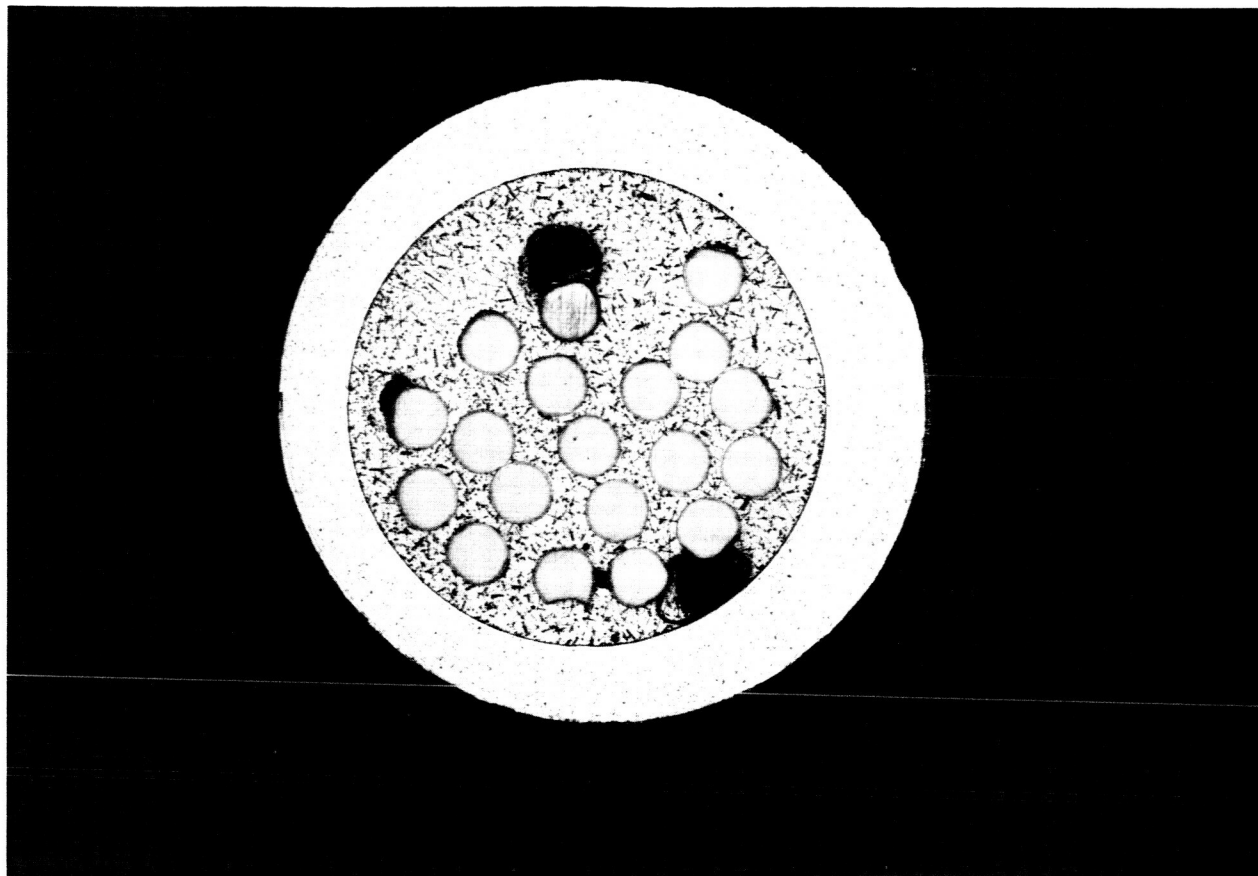
IMSC Negative No. 24738  
Magnification 15x

Enlarged view of one joint.

22 AWG-19 strand wire, silver plated, Teflon insulated,  
soldered into solder cup of #202 connector pin, using  
Alpha Metals 60/40 N. R. G. Core solder.

Note: Uneven insulation termination, due to thermal stripper  
performance. Wetting of wire incomplete.

FIGURE 8-35



IMSC Lab. No. 58573  
Test Series No. G-11

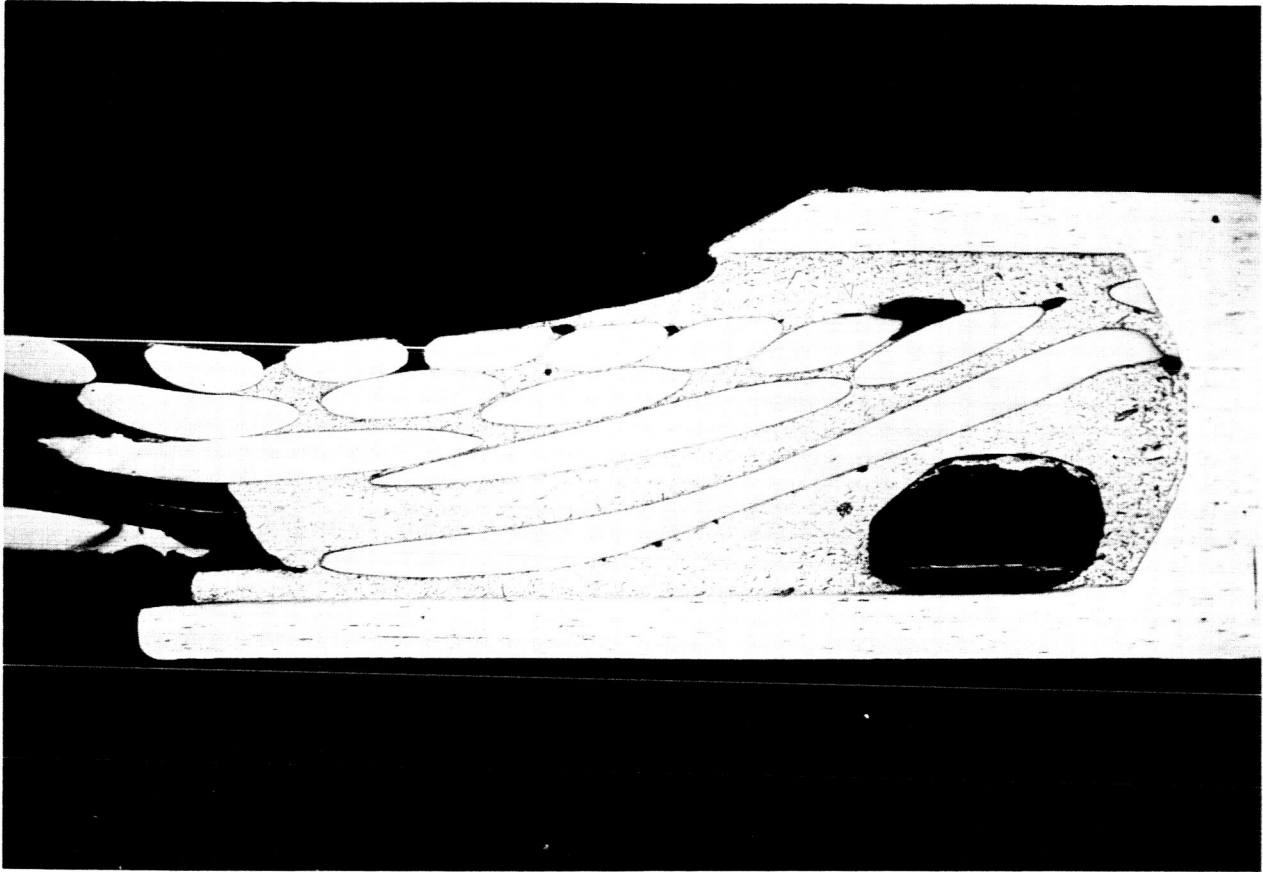
IMSC Negative No. 24804  
Magnification 50x

Transverse section through stranded wire, soldered into  
solder cup of connector pin.

22 AWG-19 strand wire, silver plated, Teflon insulated,  
soldered into solder cup of #202 connector pin, using  
Alpha Metals 60/40 N. R. G. Core solder.

Note: Voids in solder.

FIGURE 8-36



IMSC Lab. No. 58573  
Test Series G-11

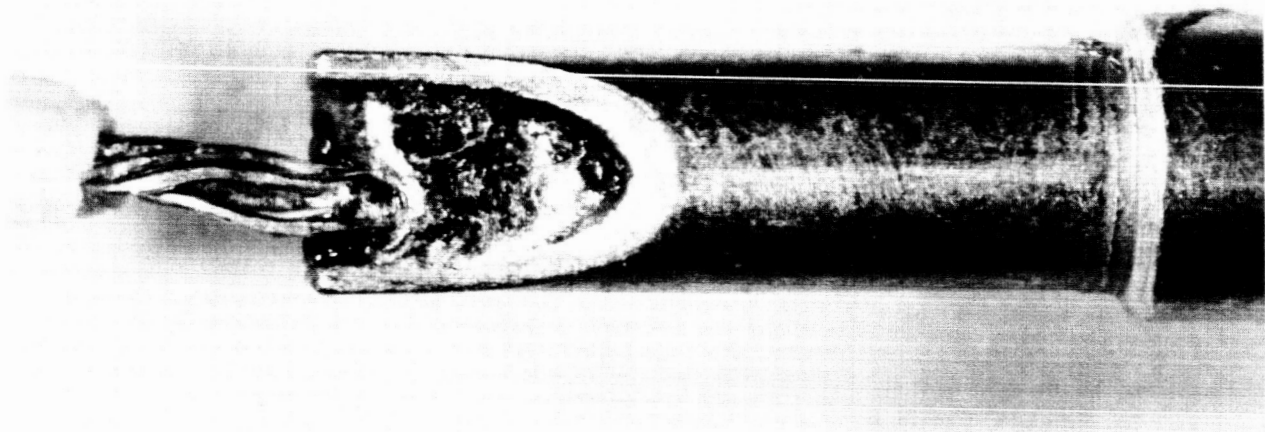
IMSC Negative No. 24809  
Magnification 35x

Longitudinal section through stranded wire-solder cup connection.

22 AWG-19 strand wire, silver plated, Teflon insulated, soldered into solder cup of #202 connector pin, using Alpha Metals 60/40 N.R.G. Core solder.

Note: Several voids in solder.

FIGURE 8-37

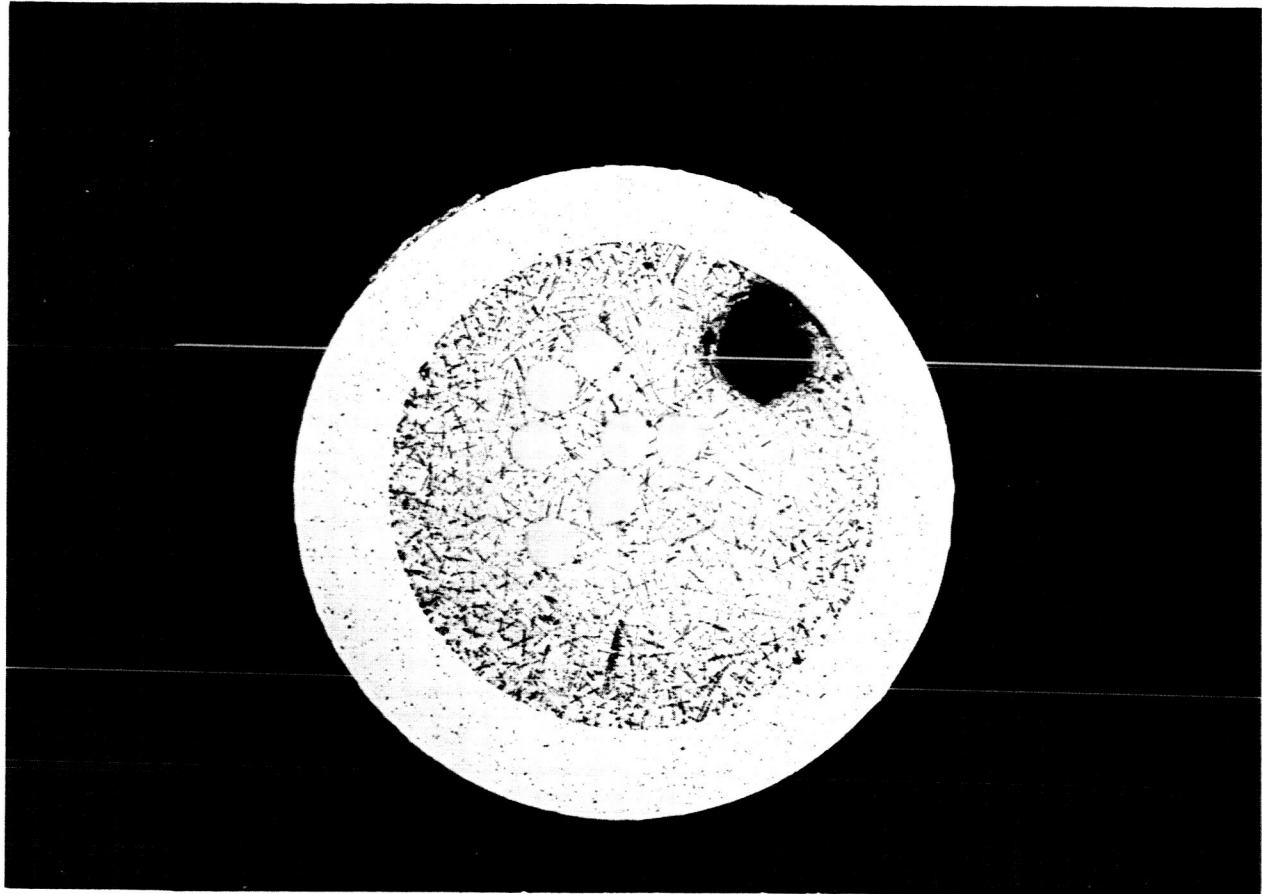


IMSC Lab. No. 58751  
Test Series G-12

IMSC Negative No. 24534  
Magnification 20x

28 AWG-7 strand wire, silver plated, Vinyl insulated, soldered  
into solder cup of #202 connector pin, using Alpha Metals  
60/40 M.R.G. Core solder.

FIGURE 8-38



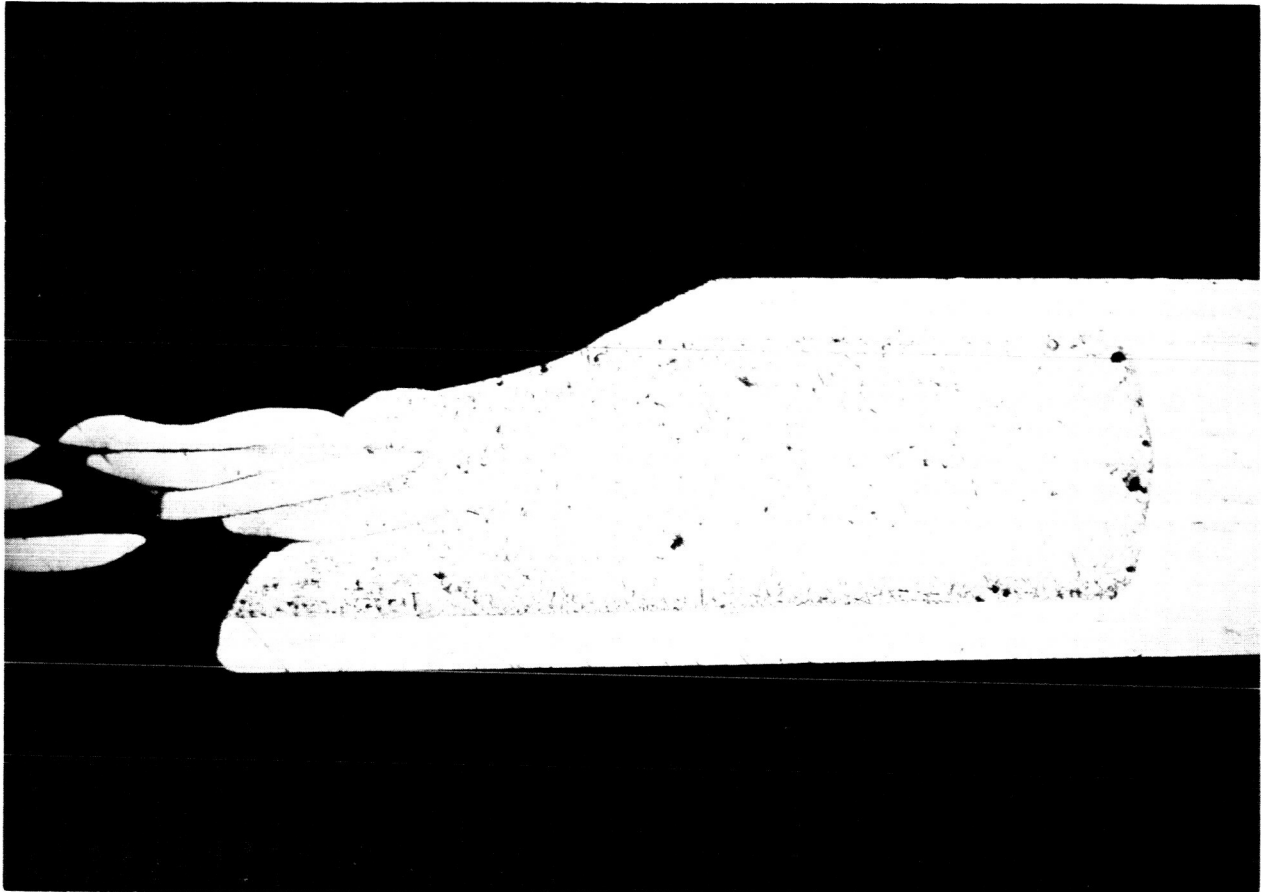
IMSC Lab. No. 58751  
Test Series G-12

IMSC Negative No. 24616  
Magnification 50x

Transverse section through soldered joint.

28 AWG-7 strand wire, silver plated, Vinyl insulated,  
soldered into solder cup of #202 connector pin, using  
Alpha Metals 60/40 N.R.G. Core solder.

FIGURE 8-39



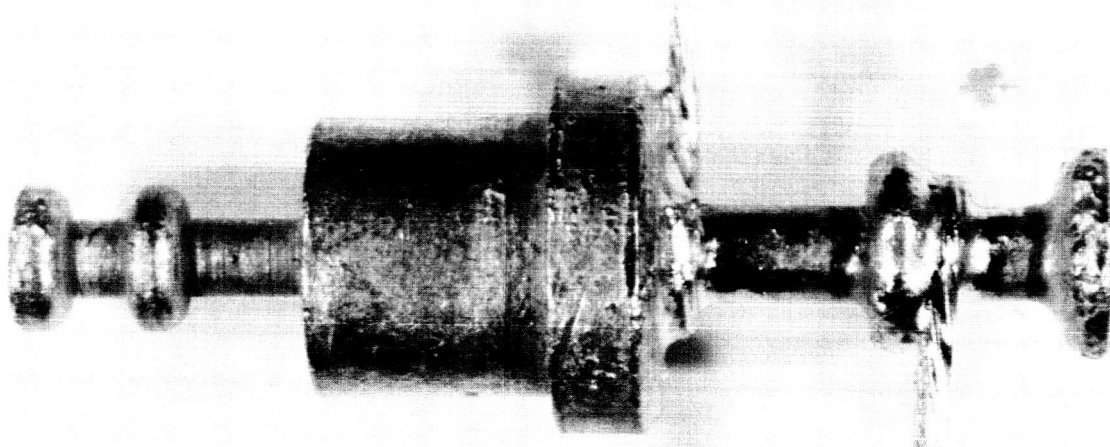
IMSC Lab. No. 58751  
Test Series No. G-12

IMSC Negative No. 24601  
Magnification 30x

Longitudinal section through soldered joint.

28 AWG-7 strand wire, silver plated, Vinyl insulated, soldered  
into solder cup of #202 connector pin, using Alpha Metals  
60/40 N.R.G. Core solder.

FIGURE 8-40



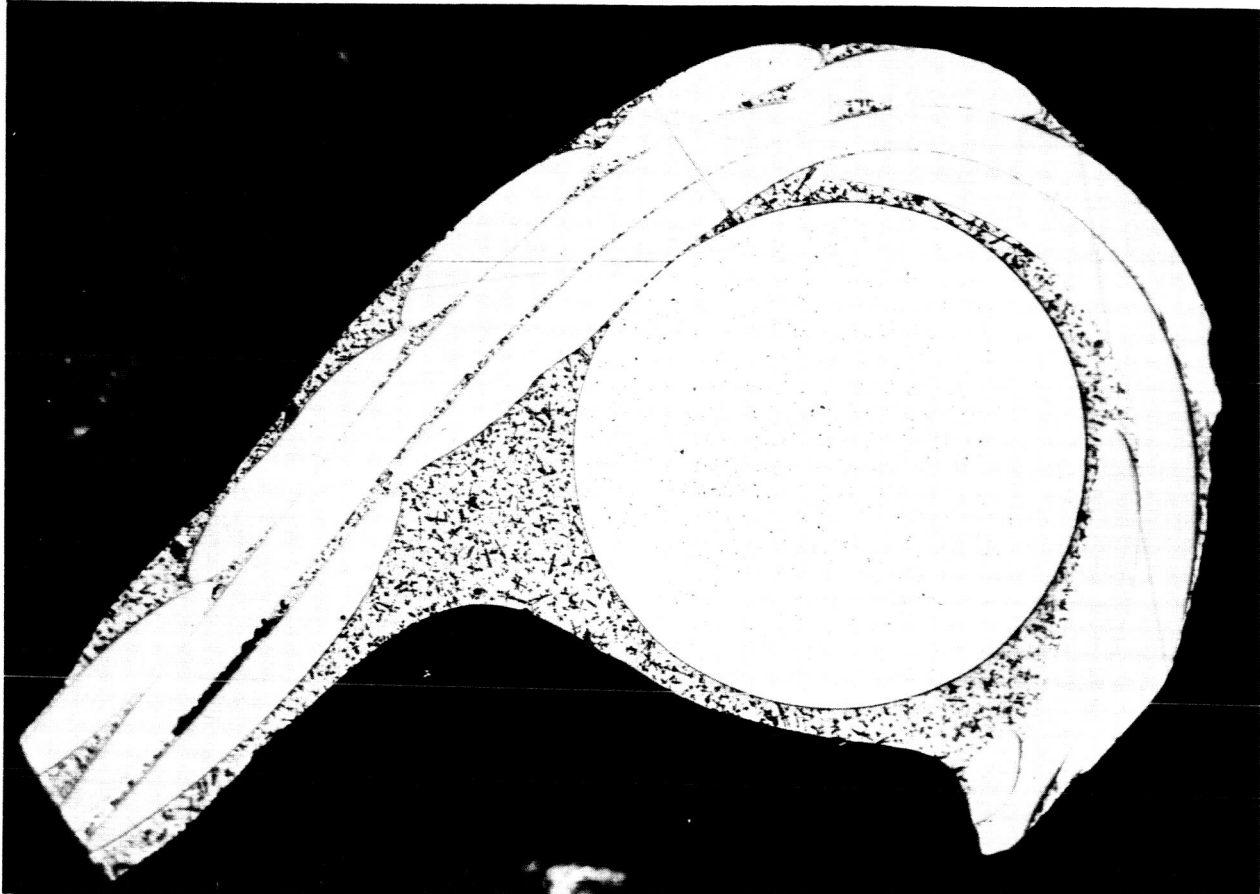
LMSC Lab. No. 58885  
Test Series G-13

LMSC Negative No. 24789  
Magnification 12x

Enlarged view of two soldered joints.

28 AWG-7 strand wire, silver plated, Vinyl insulated, bonded  
to #8958-2 turret terminal, using Alpha Metals 60/40 N.R.G.  
Core solder.

FIGURE 8-41



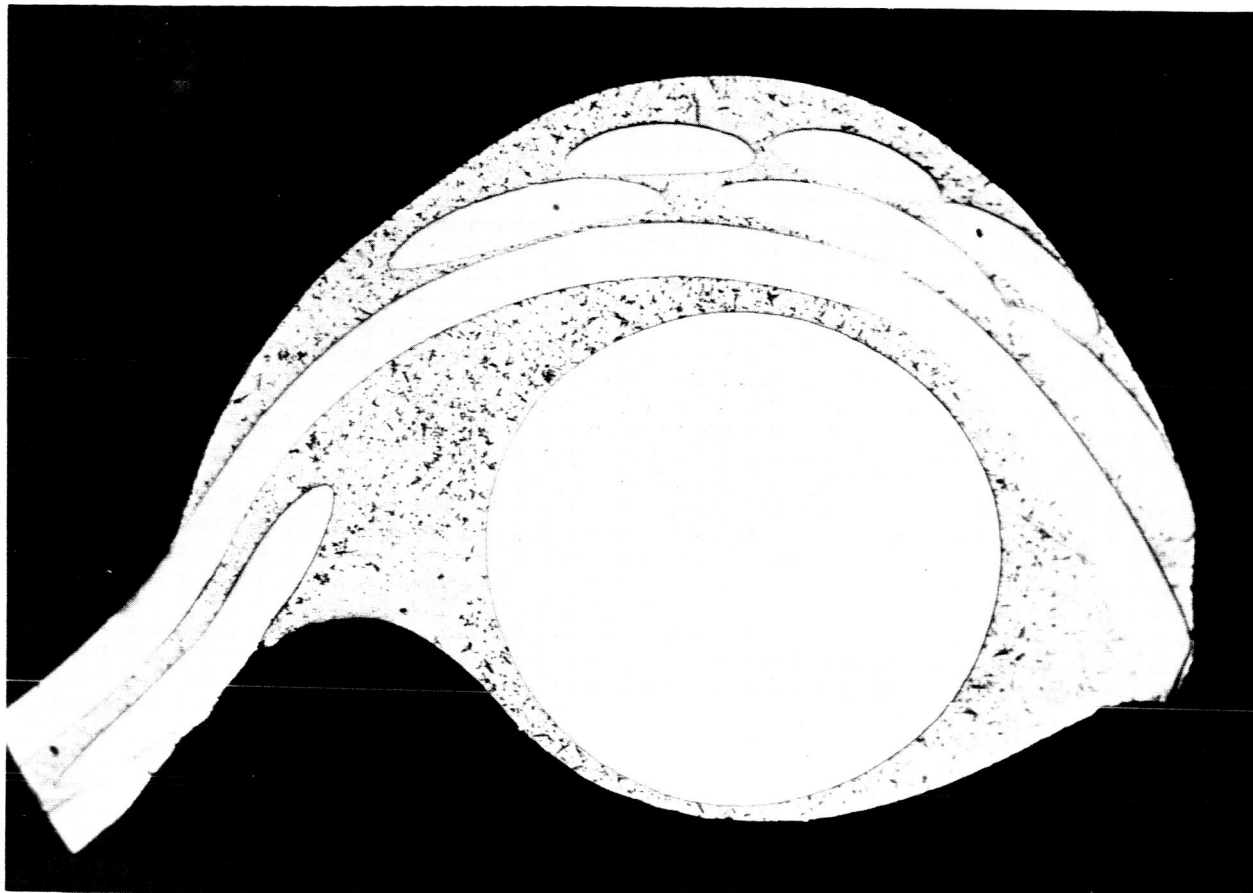
LMSC Lab. No. 58885  
Test Series G-13

LMSC Negative No. 24793  
Magnification 60x

Transverse section through lower connection.

28 AWG-7 strand wire, silver plated, Vinyl insulated,  
bonded to #8958-2 turret terminal, using Alpha Metals  
60/40 N.R.G. Core solder.

FIGURE 8-42



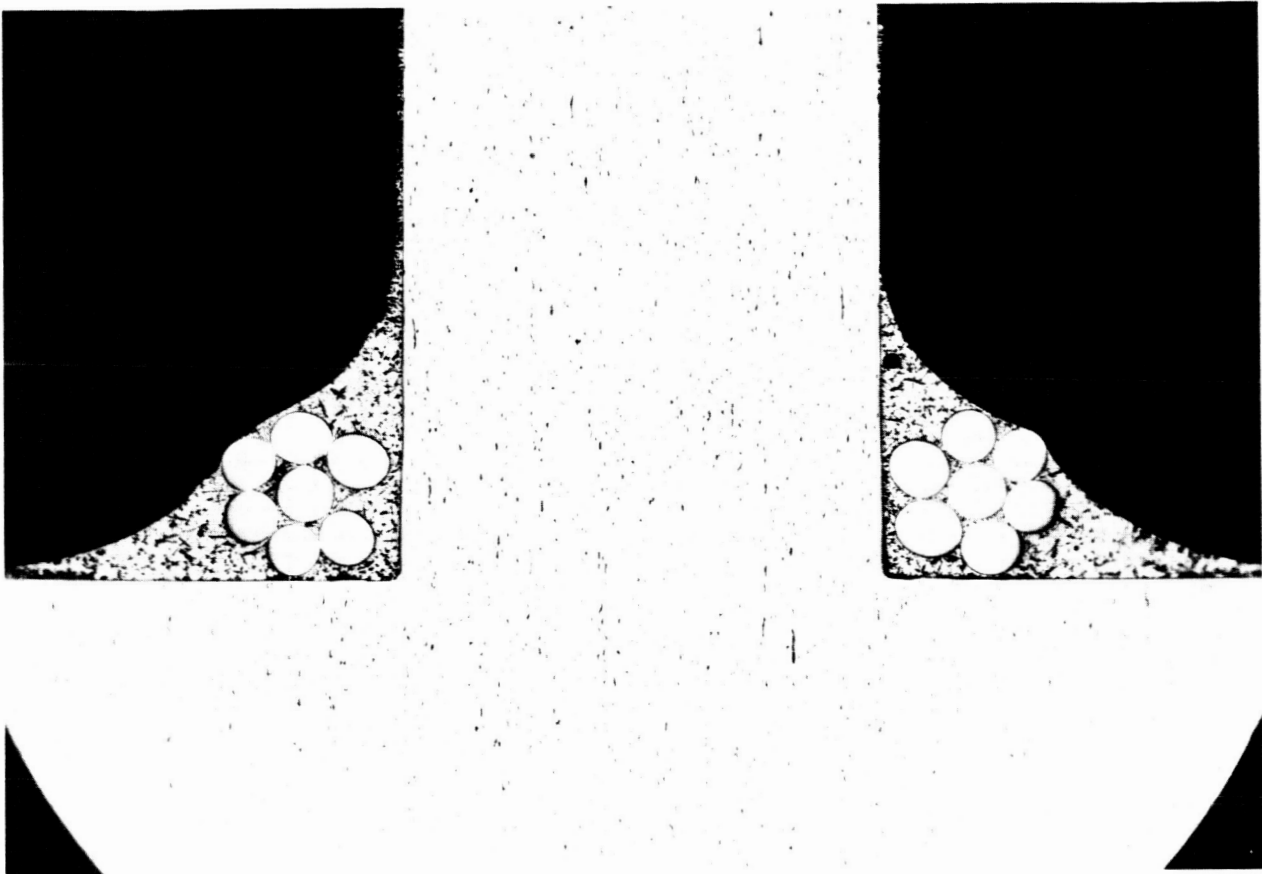
LMSC Lab. No. 58885  
Test Series No. G-13

LMSC Negative No. 24794  
Magnification 60x

Transverse section through upper connection.

28 AWG-7 strand wire, silver plated, Vinyl insulated,  
bonded to #8958-2 turret terminal, using Alpha Metals  
60/40 N.R.G. Core solder.

FIGURE 8-43



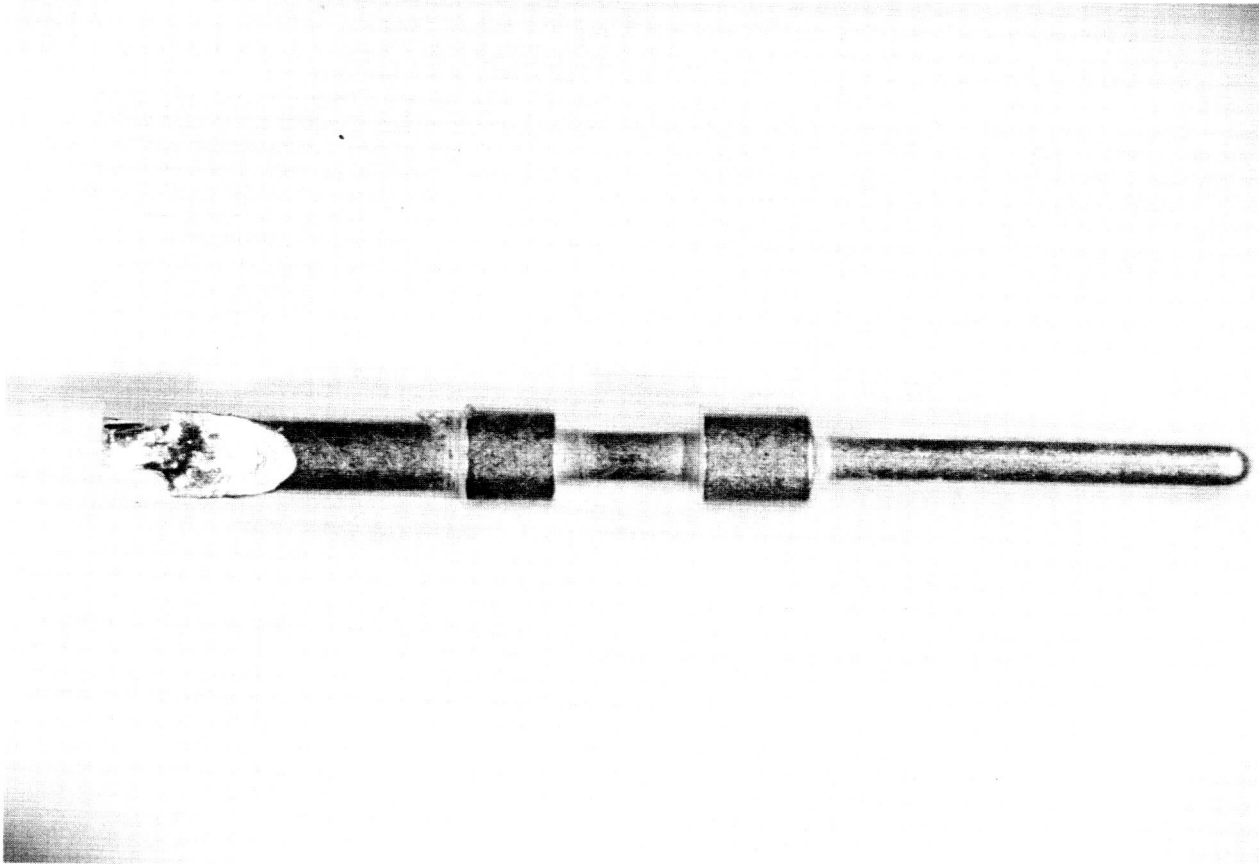
IMSC Lab. No. 58885  
Test Series G-13

IMSC Negative No. 24795  
Magnification 60x

Longitudinal section through turret.

28 AWG-7 strand wire, silver plated, Vinyl insulated, bonded to #8958-2 turret terminal, using Alpha Metals 60/40 N.R.G. Core solder.

FIGURE 8-44



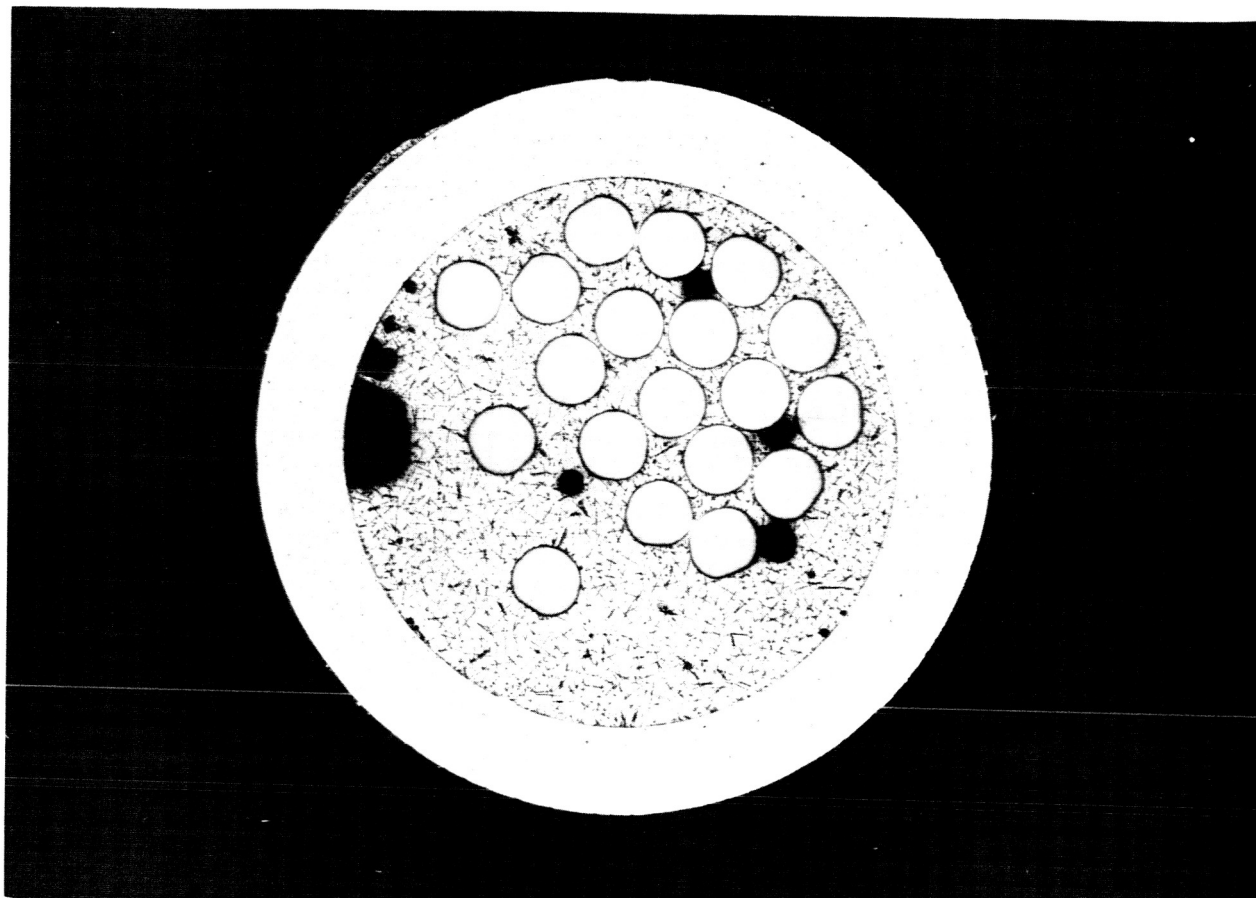
LMSC Lab. No. 58958  
Test Series G-14

LMSC Negative No. 24790  
Magnification 7x

Enlarged view of pin with soldered joint.

22 AWG-19 strand copper wire, silver plated, Vinyl insulated,  
soldered into solder cup #202 connector pin, using Alpha Metals  
60/40 Plastic Core solder.

FIGURE 8-45



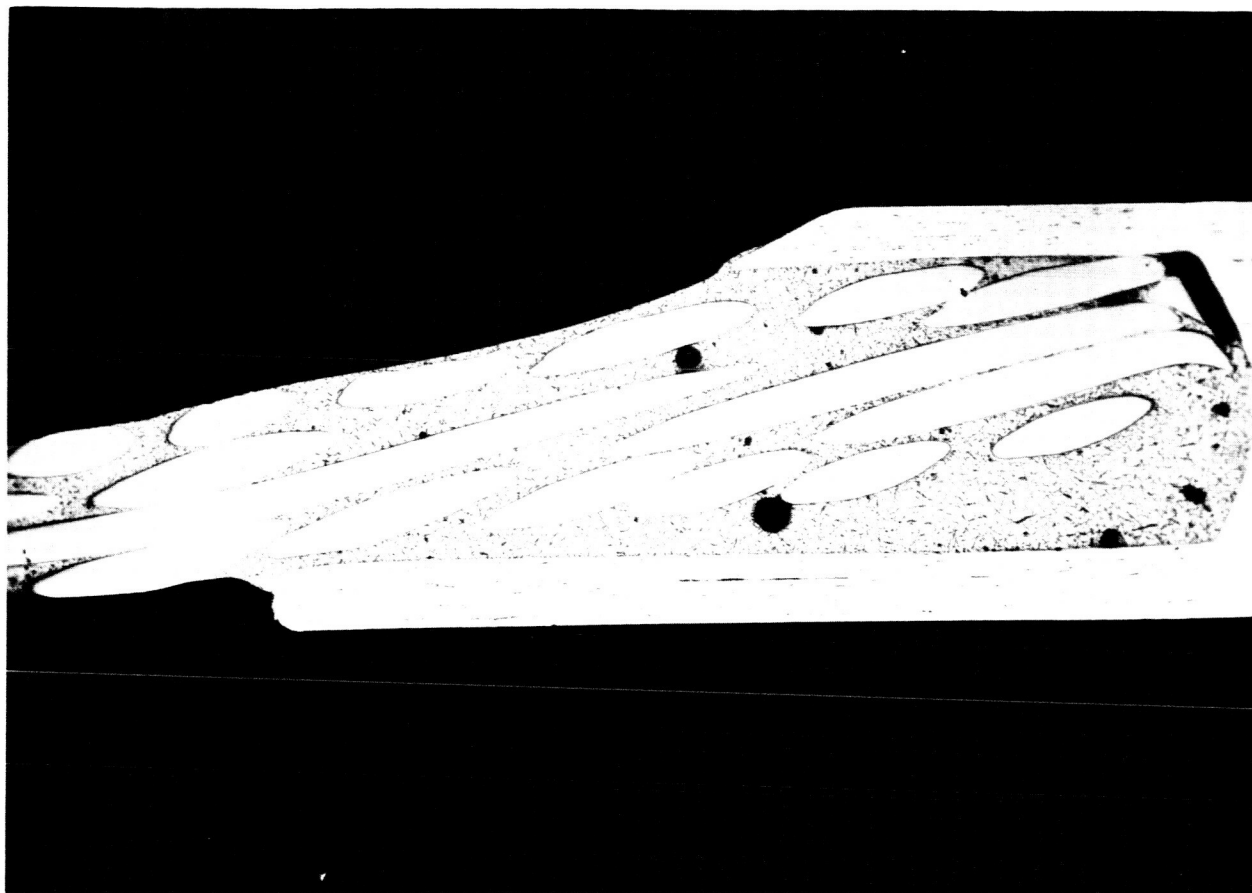
IMSC Lab. No. 58958  
Test Series G-14

IMSC Negative No. 24798  
Magnification 60x

Transverse section through soldered joint.

22 AWG-19 strand copper wire, silver plated, Vinyl insulated,  
soldered into solder cup of #202 connector pin, using Alpha  
Metals 60/40 Plastic Core solder.

FIGURE 8-46



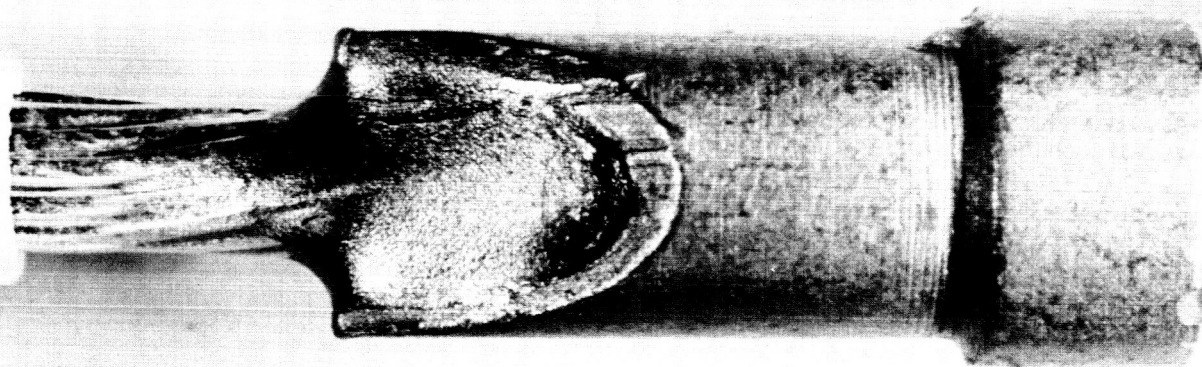
LMSC Lab. No. 58958  
Test Series G-14

LMSC Negative No. 24799  
Magnification 40x

Longitudinal section through soldered joint.

22 AWG-19 strand copper wire, silver plated, Vinyl insulated,  
soldered into solder cup of #202 connector pin, using Alpha  
Metals 60/40 Plastic Core solder.

FIGURE 8-47



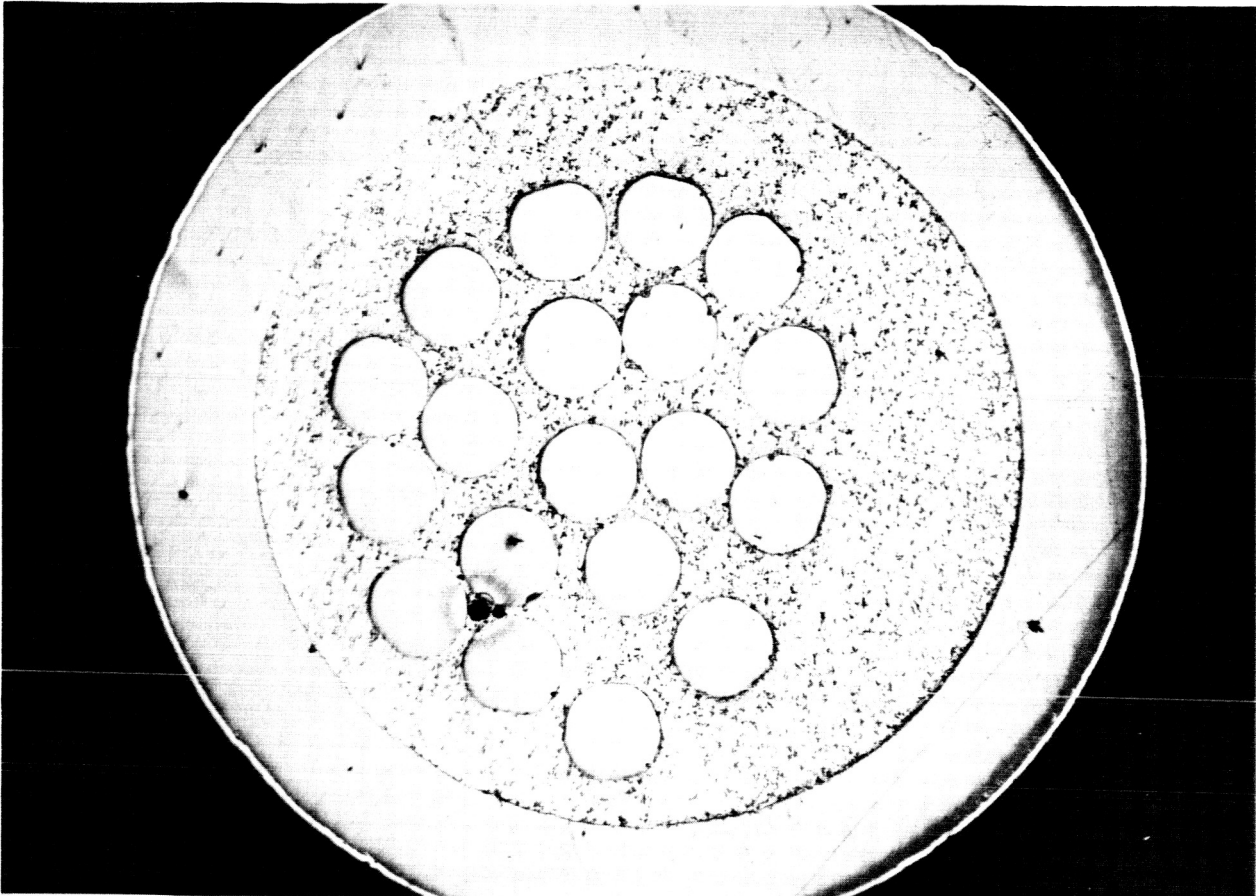
IMSC Lab. No. 59024  
Test Series No. G-15

IMSC Negative No. 24840  
Magnification 16x

Enlarged view of representative joint.

18 AWG-19 strand copper wire, silver plated, Vinyl insulated,  
soldered into solder cup of #162 connector pin, using Alpha  
Metals 60/40 Plastic Core solder.

FIGURE 8-48



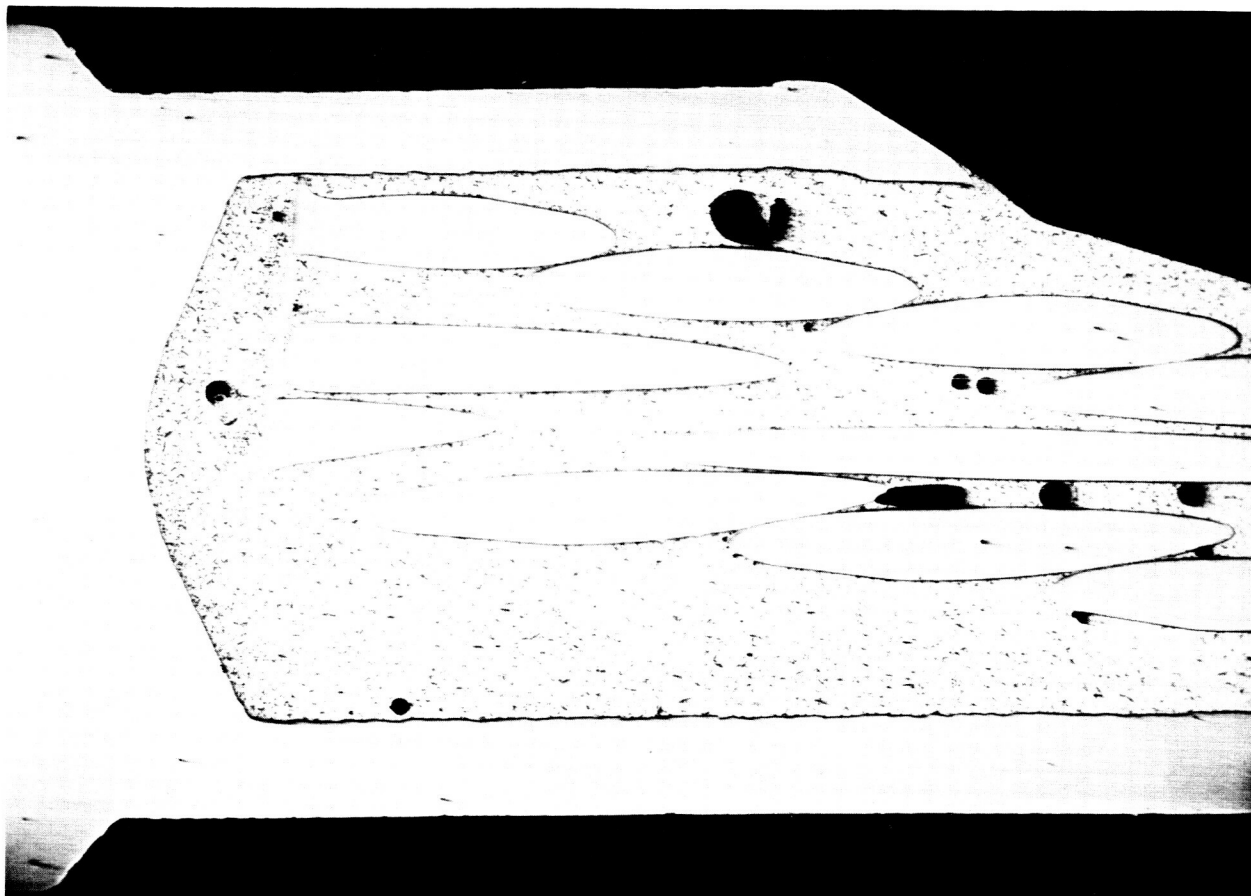
LMSC Lab. No. 59024  
Test Series G-15

LMSC Negative No. 24954  
Magnification 50x

Transverse section through typical joint.

18 AWG-19 strand copper wire, silver plated, Vinyl insulated, soldered into solder cup of #162 connector pin, using Alpha Metals 60/40 Plastic Core solder.

FIGURE 8-49



LMSC Lab. No. 59024  
Test Series G-15

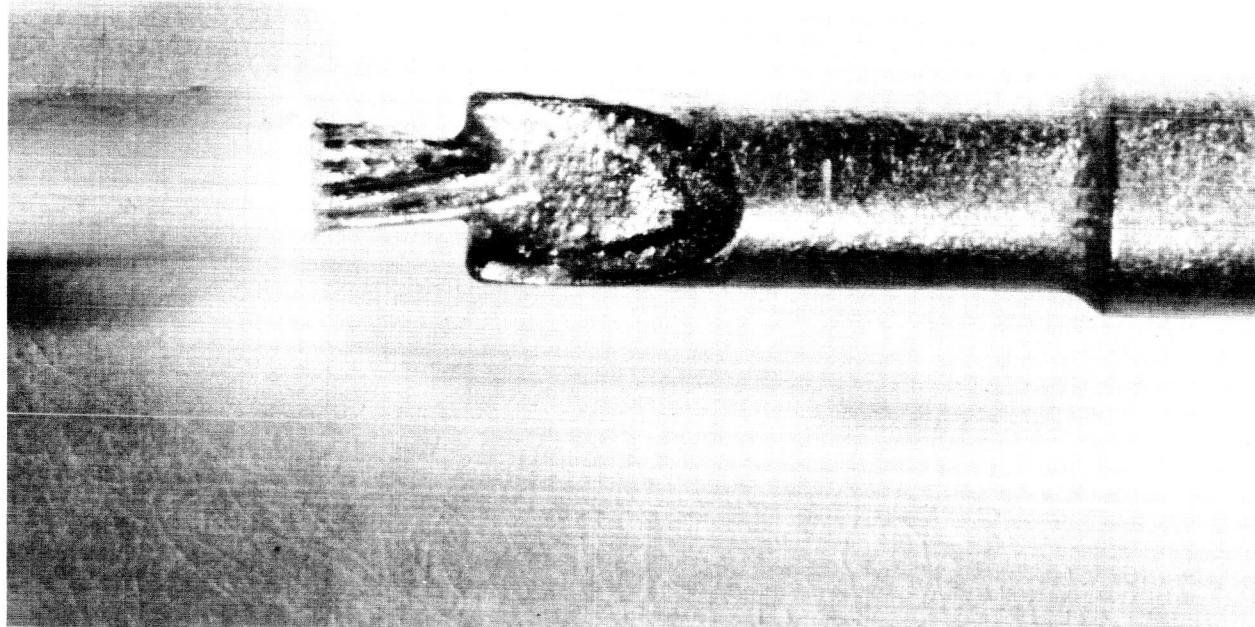
LMSC Negative No. 24955  
Magnification 40x

Longitudinal section through solder joint.

18 AWG-19 strand copper wire, silver plated, Vinyl insulation,  
soldered into solder cup of #162 connector pin, using Alpha  
Metals 60/40 Plastic Core solder.

8-65

FIGURE 8-50



LMSC Lab. No. 59134  
Test Series G-16

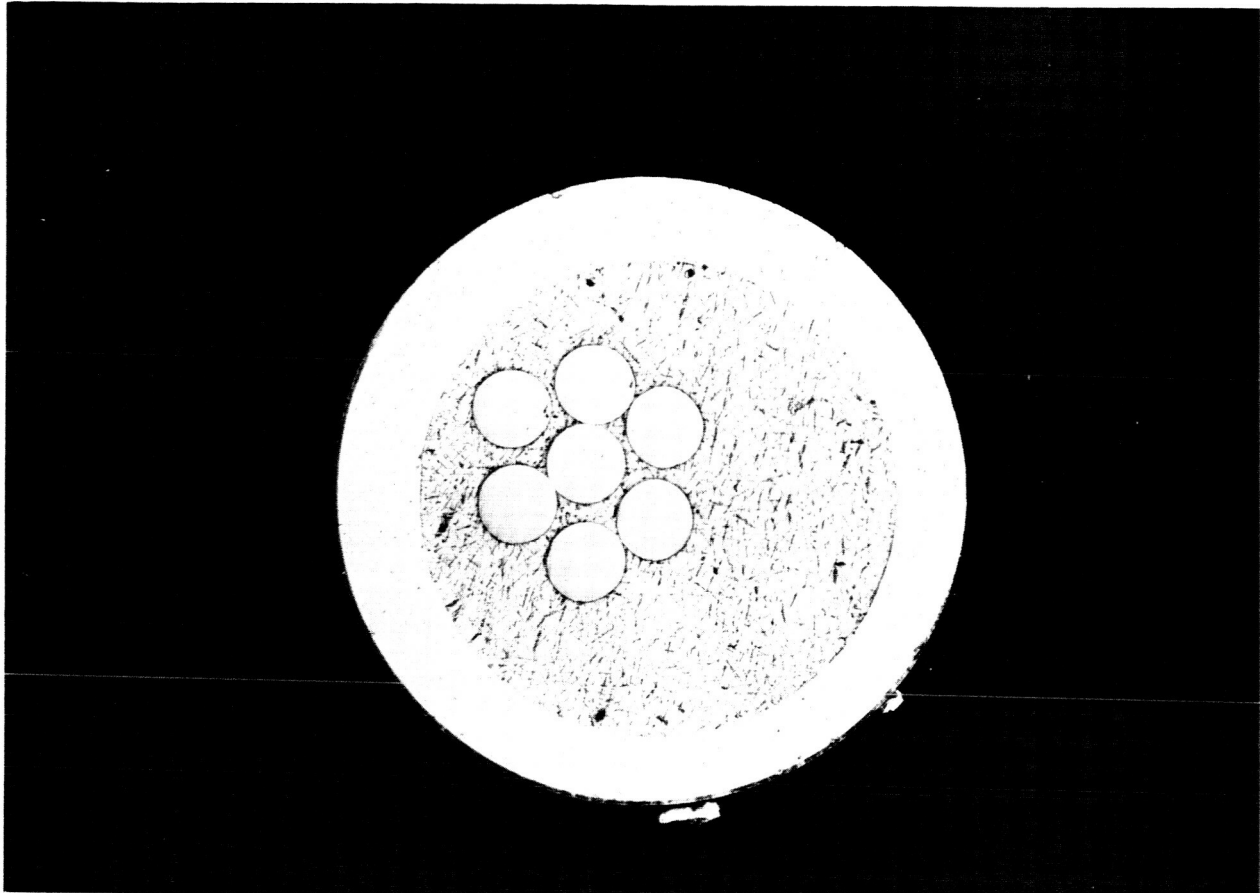
LMSC Negative No. 24841  
Magnification 16x

Enlarged view of typical joint.

24 AWG-7 strand copper wire, nickel plated Vinyl insulated,  
soldered into solder cup of #202 connector pin, using Alpha  
Metals 60/40 N.R.G. Core solder.

8-66

FIGURE 8-51



IMSC Lab. No. 59134  
Test Series G-16

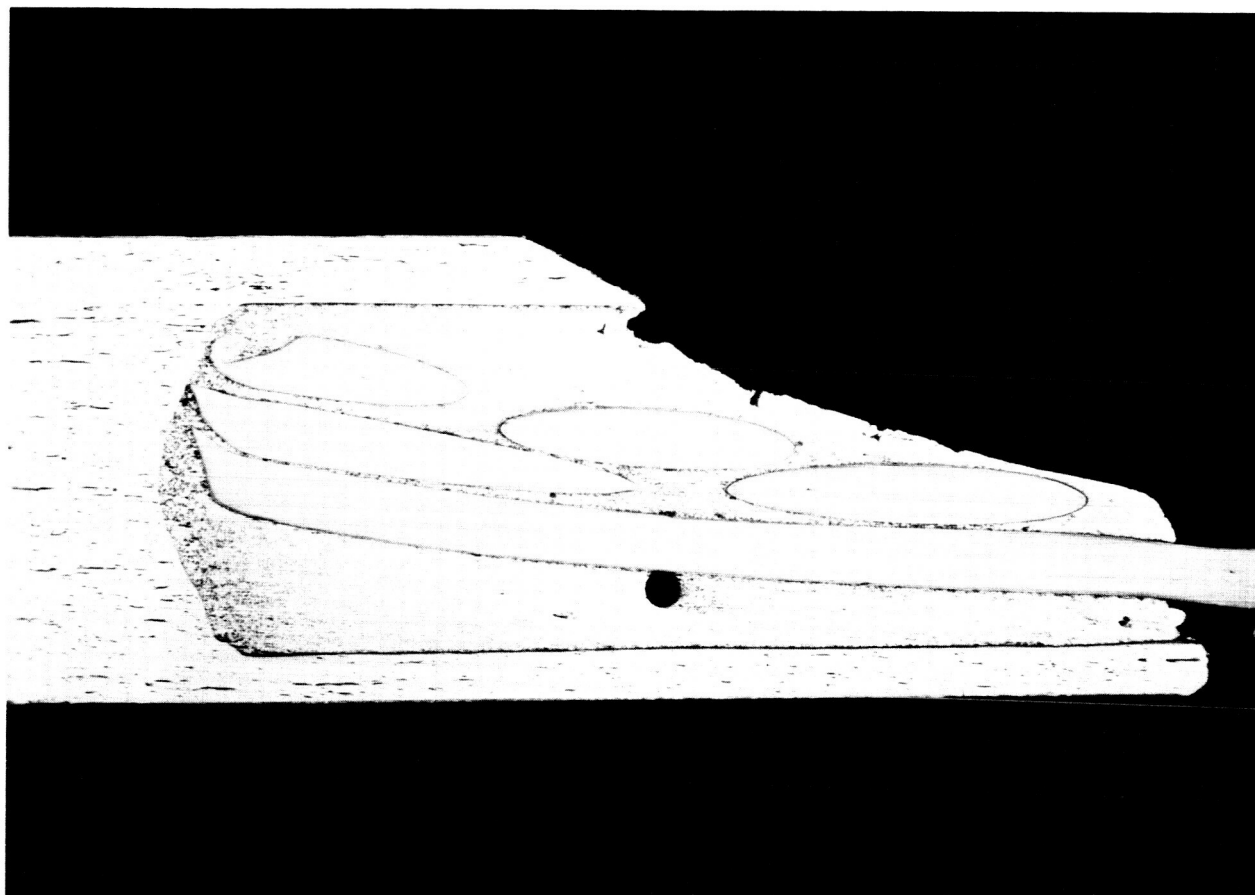
IMSC Negative No. 24596  
Magnification 50x

Transverse section through typical joint.

24 AWG-7 strand copper wire, nickel plated, Vinyl insulated,  
soldered into solder cup of #202 connector pin, using Alpha  
Metals 60/40 N.R.G. Core solder.

8-67

FIGURE 8-52



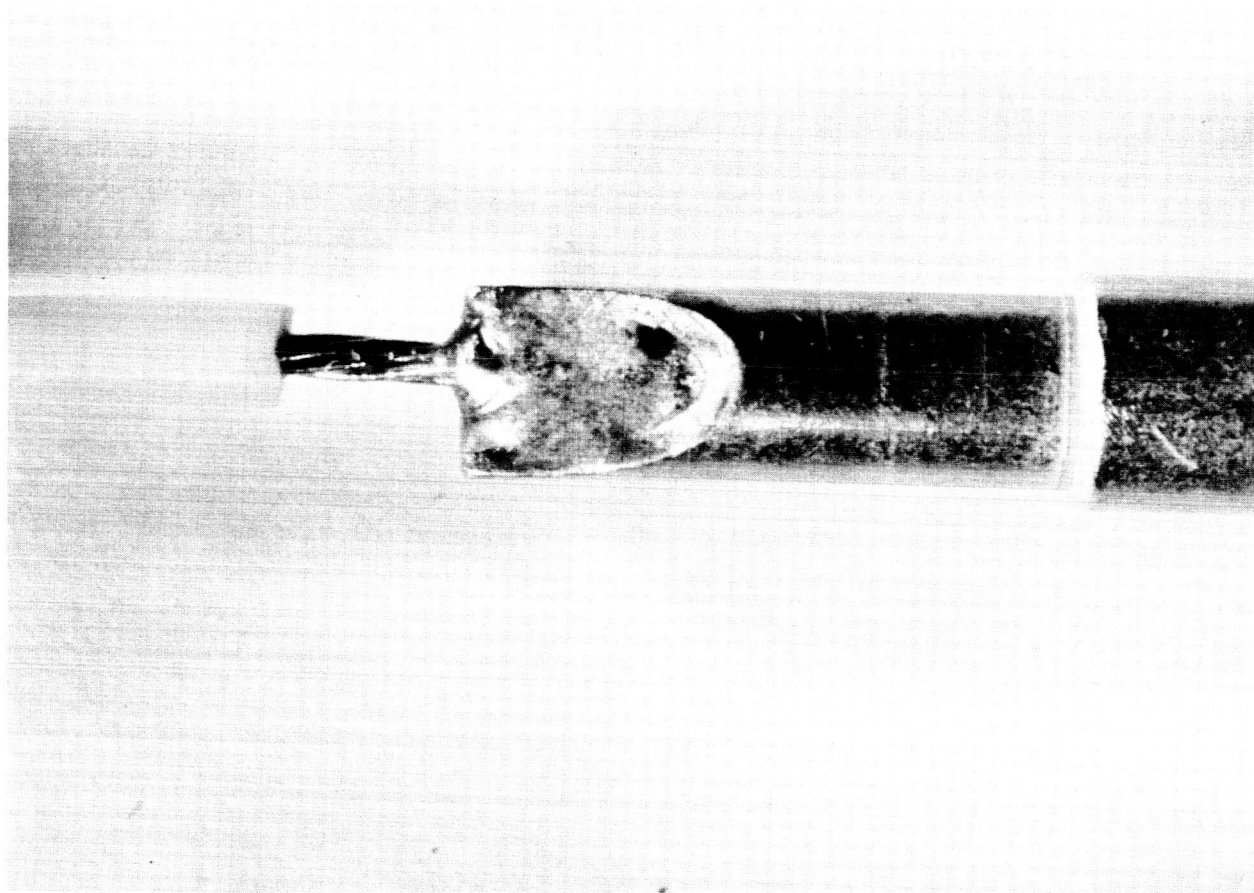
LMSC Lab. No. 59134  
Test Series G-16

LMSC Negative No. 24957  
Magnification 40x

Longitudinal section through typical joint.

24 AWG-7 strand copper wire, nickel plated, Vinyl insulated,  
soldered into solder cup of #202 connector pin, using Alpha  
Metals 60/40 N.R.G. Core solder.

FIGURE 8-53



IMSC Lab. No. 59186  
Test Series G-17

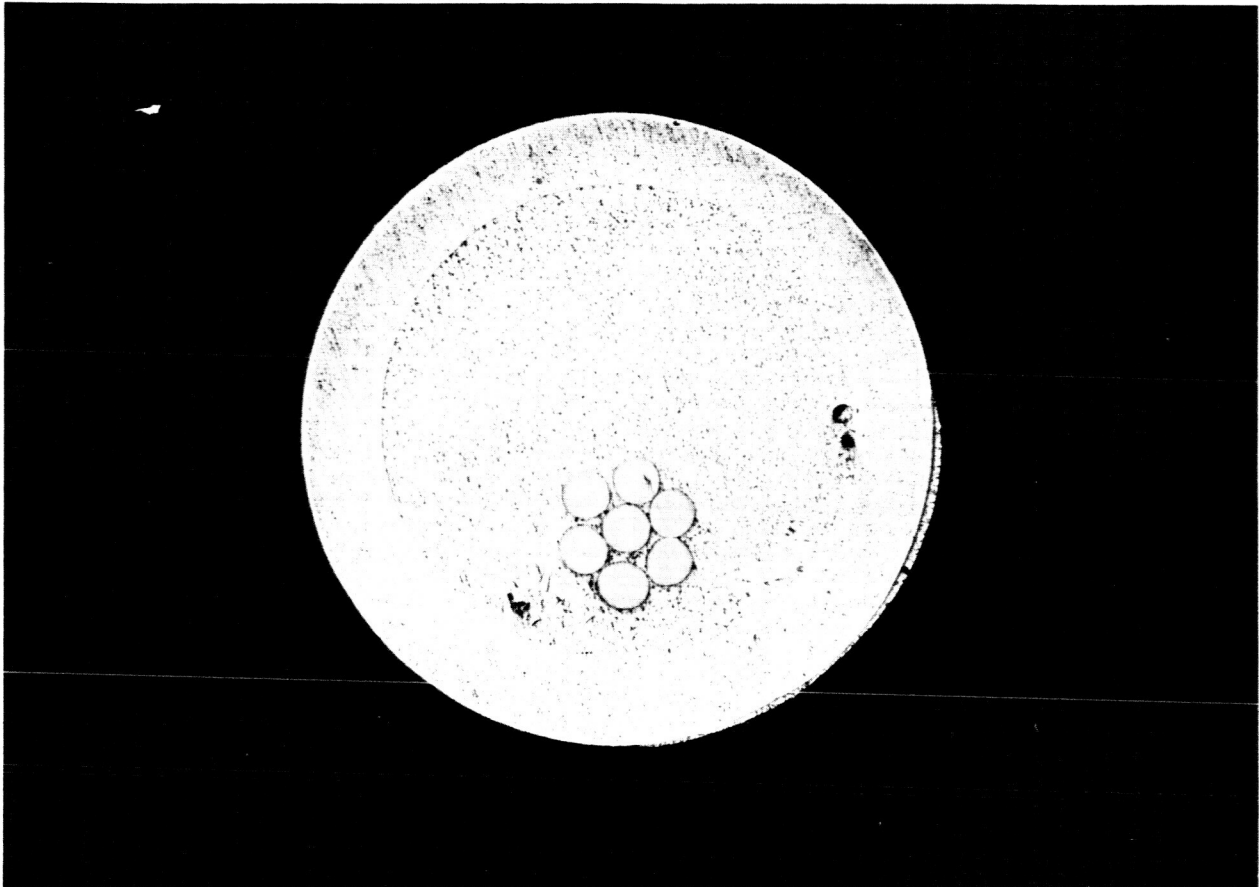
IMSC Negative No. 24842  
Magnification 16x

Enlarged view of typical joint.

28 AWG-7 strand copper wire, nickel plated, Vinyl insulated,  
soldered into solder cup of #202 connector pin, using Fairmount  
60/40 H-32 Core solder.

8-69

FIGURE 8-54



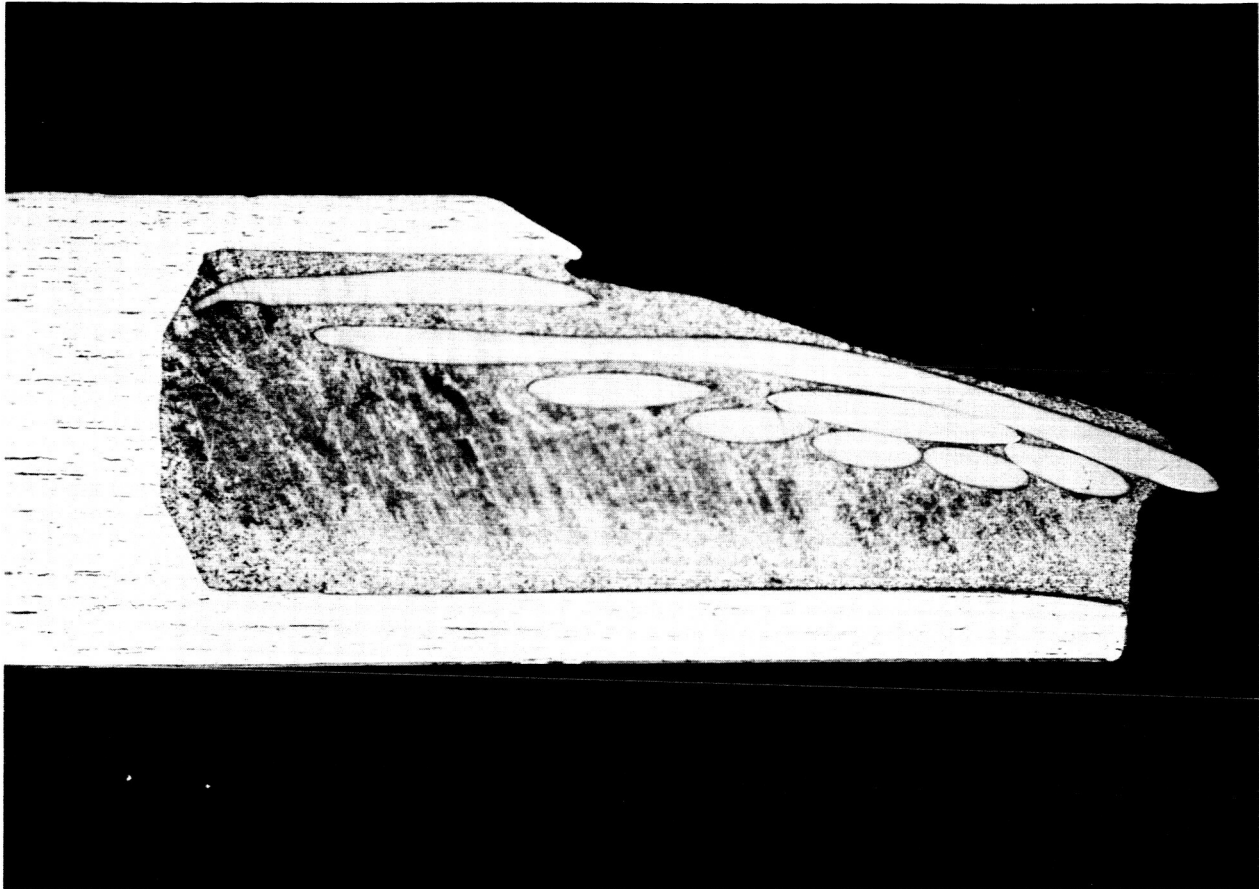
LMSC Lab. No. 59186  
Test Series G-17

LMSC Negative No. 24952  
Magnification 50x

Transverse section through typical joint.

28 AWG-7 strand copper wire, nickel plated, Vinyl insulated,  
soldered into solder cup of #202 connector pin, using Fairmount  
60/40 H-32 Core solder.

FIGURE 8-55



IMSC Lab. No. 59186  
Test Series G-17

IMSC Negative No. 24953  
Magnification 40x

Longitudinal section through typical joint.

28 AWG-7 strand copper wire, nickel plated, Vinyl insulated,  
soldered into solder cup of #202 connector pin, using Fairmount  
40/40 H-32 Core solder.

## Section 9

## APPENDIX

The contents of this appendix are related to the tests reported under Sections 7 and 8.

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
9.1	Insulated Stranded Wires	9-2
9.2	Cleaning Solvents	9-4
9.3	Fatigue Resistance Test Equipment	9-5
9.4	Test Data Sheets for Subtask (f)	9-7
9.5	Test Data Sheets for Subtask (g)	9-20

# 9.1 INSULATED STRANDED WIRES

- Wire, stranded, silver-plated, Teflon insulation

AWG 18	19 strand	(g)
AWG 22	19 strand	(f) (g)
AWG 24	7 strand	(g)
AWG 28	7 strand	(g)

Procured from Victor Wire and Cable Corporation,  
3601 Holdridge, Los Angeles, California

- Wire, stranded, nickel-plated, Teflon insulation

AWG 18	19 strand	
AWG 22	19 strand	(f) (g)
AWG 24	7 strand	(f) (g)
AWG 28	7 strand	(g)

Procured from Victor Wire and Cable Corporation,  
3601 Holdridge, Los Angeles, California

- Wire, stranded, silver-plated, Vinyl insulation

AWG 18	19 strand	(g)
AWG 22	19 strand	(g)
AWG 24	7 strand	
AWG 28	7 strand	(g)

Procured from Philadelphia Insulated Wire Company,  
c/o The K. W. Lockwood Co., 1516 Westwood Blvd.,  
Los Angeles, California.

## 9.1 (Continued)

- Wire, stranded, nickel-plated, Vinyl insulation

AWG 18	19 strand	
AWG 22	19 strand	
AWG 24	7 strand	(g)
AWG 28	7 strand	(g)

Procured from Philadelphia Insulated Wire Company,  
c/o The K. W. Lockwood Co., 1516 Westwood Blvd.,  
Los Angeles, California

- Wire, stranded, tin-lead solder-plated, Vinyl insulation

AWG 18	19 strand	(g)
AWG 22	19 strand	
AWG 24	7 strand	(g)
AWG 28	7 strand	(g)

Procured from Victor Wire and Cable Corporation,  
3601 Holdridge, Los Angeles, California

Letter in parenthesis, i.e., (g), indicates subtask for which the  
stranded wire has been used.

All wires were in compliance with Specification MIL-W-16878.

9.2 CLEANING SOLVENTS

Trichlorethylene. 1, 1, 1 - trichloroethylene

(a) Procured to Specification MIL-T-7003 on Open Bid

(b) Inhibited to scavenge HCl formed by hydrolysis

Methyl Chloroform. (1, 1, 1 - trichlorethane)

Procurement Specification O-T-620A on Open Bid

TMC Freon (formula proprietary)

Procurement : DuPont de Nemours

• Tested to IMSC Material Std. 208-3S-6250-230 upon receipt of material.

### 9.3 FATIGUE RESISTANCE TEST EQUIPMENT

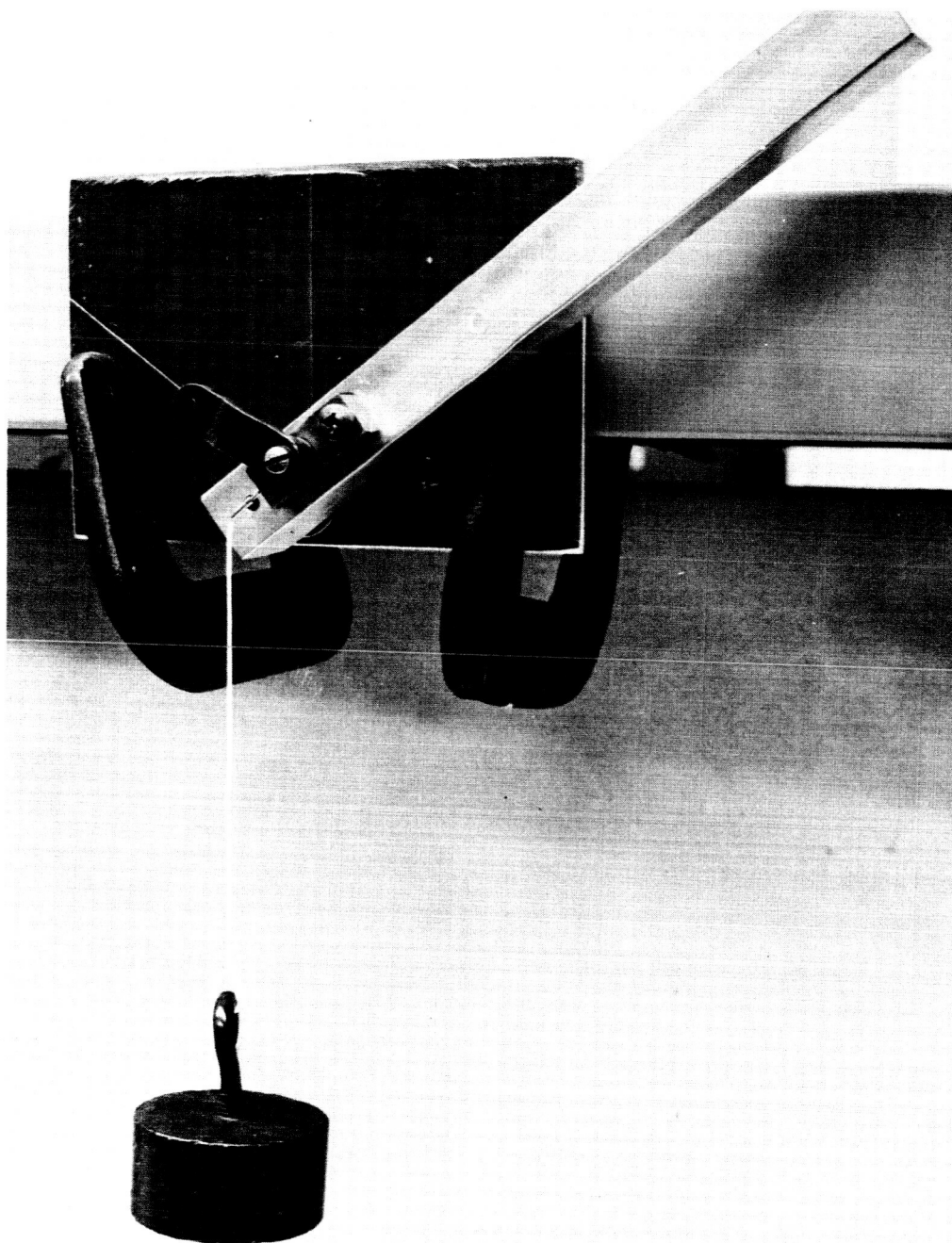
The determination of fatigue resistance of the wicked wires was performed by using a laboratory-built testing device, which is illustrated in Figure 9-1 and operates as follows:

A clamp of suitable size to accept the solder-dipped end of the stranded wire or the solder cup in is attached to a mechanically operated lever. This lever moves through a preset angle, usually  $\pm 55^\circ$  of arc from the vertical. This provides the bending action. The lower free end of the wire under test carries the weight which provides the necessary tension. In the tests under this project, the weight was one (1) pound.

The method used to clamp the test specimen is important because it considerably influences the test result. For the tests performed under this project, a clamping method was selected which resulted in flexing only the wicked section of the stranded cable.

- Free cable ends were clamped as close to the insulation as possible. This assures that bending takes place in the wicked length of the cable.
- Solder cup ends were clamped at their free end, opposite the solder cup as shown in the photograph. This method places the bending point directly outside of the solder cup, that is, in the wicked length of the cable.

FIGURE 9-1



FATIGUE RESISTANCE TEST EQUIPMENT

Paragraph 9.4

Test Data Sheets for Subtask (f)

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

A1, A2, A3, A4

Lab. Report Number:

57 922

Specimen: Nickel-plated copper wire, Teflon insulation

No. of Specimens: 36

Wire Gauge: 22                      AWG.                      Number of Strands: 19

Strip Gap: 1/8 inch

Soldering Method:                      ( X ) Pot                      (   ) Soldering Iron

Solder Used: Alpha Metals 60/40

Flux Used: Alpha Metals #346-25 liquid

Cleaning Method (Before Soldering): brushing in 1,1,1 - trichloroethane

Soldering Temperature: 400°F

Immersion Time: 5,20,40,80 Seconds.                      Immersion Depth: 1/8"                      Inch

Heat Sink Used:                      (   ) Yes                      ( X ) No

## Fatigue Tests:

A1:	45	39	37	36	31	29	21			$\bar{x} = 34$	$\sigma = 7.8$
A2:	51	46	35	30	25	19	16	16	16	$\bar{x} = 28$	$\sigma = 13.4$
A3:	39	25	25	22	20	19	19	17	10	$\bar{x} = 22$	$\sigma = 7.9$
A4:	34	33	31	22	21	20	18	16	15	$\bar{x} = 23$	$\sigma = 7.4$

## Remarks:

Photomicrographs: No. 24 085 and No. 24 087

Wicking depth:

A1:	0.150 inch
A2:	0.355 inch
A3:	0.585 inch
A4:	0.460 inch

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

Lab. Report Number:

A5, A6, A7, A8

57 947

Specimen: Nickel plated copper wire, Teflon insulation

No. of Specimens: 40

Wire Gauge: 22                      AWG.                      Number of Strands: 19

Strip Gap: 1/8 inch

Soldering Method:                      ( ☒ ) Pot                      (    ) Soldering Iron

Solder Used: Alpha Metals 60/40

Flux Used: Alpha Metals #346-25 liquid

Cleaning Method (Before Soldering): brushing in 1,1,1 - trichloroethane

Soldering Temperature: 450°F

Immersion Time: 5,20,40,80 Seconds                      Immersion Depth: 1/8                      Inch

Heat Sink Used:                      (    ) Yes                      ( ☒ ) No

## Fatigue Tests:

A5:	40	37	36	35	31	30	28	23	22	21	$\bar{x} = 30$	$\sigma = 6.7$
A6:	24	23	16	15	15	14	14	13	12	11	$\bar{x} = 16$	$\sigma = 4.4$
A7:	39	20	19	18	17	16	16	15	14	12	$\bar{x} = 19$	$\sigma = 7.6$
A8:	27	22	21	21	17	17	17	16	15	12	$\bar{x} = 19$	$\sigma = 4.3$

## Remarks:

Wicking Depths:

A5:	0.510 inch
A6:	0.745 inch
A7:	0.755 inch
A8:	0.785 inch

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

Lab. Report Number:

A9, A10, A11, A12

58 020

Specimen: Nickel-plated copper wire, Teflon insulation

No. of Specimens: 40

Wire Gauge: 22 AWG. Number of Strands: 19

Strip Gap: 1/8 inch

Soldering Method: (X) Pot ( ) Soldering Iron

Solder Used: Alpha Metals 60/40

Flux Used: Alpha Metals #346-25 liquid

Cleaning Method (Before Soldering): brushing in 1, 1, 1 - trichloroethane

Soldering Temperature: 500°F

Immersion Time: 5, 20, 40, 80 Seconds Immersion Depth: 1/8 Inch

Heat Sink Used: ( ) Yes (X) No

## Fatigue Tests:

A9:	52	49	42	37	33	32	28	25	21	28	$\bar{x} = 35$	$\sigma = 10.2$
A10:	33	31	30	27	25	24	23	23	15	15	$\bar{x} = 25$	$\sigma = 6.1$
A11:	30	23	18	17	16	16	14	14	14	13	$\bar{x} = 15$	$\sigma = 5.9$
A12:	42	18	18	17	16	16	16	15	14	8	$\bar{x} = 18$	$\sigma = 8.9$

## Remarks:

Wicking depth:	A9:	0.510 inch
	A10:	0.200 inch
	A11:	0.495 inch
	A12:	0.395 inch

TEST DATA SHEET  
Integrity of Electrical Connections  
Contract NAS 8-11475

Test Series Number:

A13, A14, A15, A16

Lab. Report Number:

58 104

Specimen: nickel-plated copper wire, Teflon insulation

No. of Specimens: 40

Wire Gauge: 22                      AWG.                      Number of Strands: 19

Strip Gap: 1/8 inch

Soldering Method:                      (X) Pot                      ( ) Soldering Iron

Solder Used: Alpha Metals 60/40

Flux Used: Alpha Metals #346-25 liquid

Cleaning Method (Before Soldering): Brushing in 1, 1, 1 - trichloroethane

Soldering Temperature: 550°F

Immersion Time: 5, 20, 40, 80 Seconds.                      Immersion Depth: 1/8                      Inch

Heat Sink Used:                      ( ) Yes                      (X) No

#### Fatigue Tests:

A13:	48	45	42	38	36	31	27	26	22	18	$\bar{x} = 33$	$\sigma = 10.1$
A14:	44	26	25	24	23	21	22	20	18	17	$\bar{x} = 24$	$\sigma = 7.7$
A15:	43	27	24	19	19	19	18	18	16	14	$\bar{x} = 22$	$\sigma = 5.9$
A16:	21	21	18	17	17	16	16	15	13	12	$\bar{x} = 17$	$\sigma = 3.0$

#### Remarks:

Wicking depth:	A13:	0.375 inch
	A14:	0.425 inch
	A15:	0.725 inch
	A16:	0.850 inch

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

A17, A18, A19, A20

Lab. Report Number:

58 197

Specimen: Silver-plated copper wire, Teflon insulation

No. of Specimens: 40

Wire Gauge: 22 AWG. Number of Strands: 19

Strip Gap: 1/8 inch

Soldering Method: (X) Pot ( ) Soldering Iron

Solder Used: Alpha Metals 60/40

Flux Used: Alpha Metals #346-25 liquid

Cleaning Method (Before Soldering): brushing in 1, 1, 1-trichloroethane

Soldering Temperature: 550°F

Immersion Time: 5, 20, 40, 80 Seconds Immersion Depth: 1/8 Inch

Heat Sink Used: ( ) Yes (X) No

## Fatigue Tests:

A17:	20 11 11 9 9 9 8 7 7 7	$\bar{x} = 9.8$	$\sigma = 3.9$
A18:	10 10 10 9 9 9 9 8 8	$\bar{x} = 9.1$	$\sigma = 0.91$
A19:	10 10 9 9 8 8 8 8 7 7	$\bar{x} = 8.4$	$\sigma = 1.1$
A20:	12 10 9 9 9 8 8 8 8 7	$\bar{x} = 9.0$	$\sigma = 1.5$

## Remarks:

Wicking depth: A17: 0.475 inch  
 A18: 0.825 inch  
 A19: 0.835 inch  
 A20: 0.735 inch

TEST DATA SHEET  
Integrity of Electrical Connections  
Contract NAS 8-11475

Test Series Number:  
A 21, A 22, A 23, A 24

Lab. Report Number:  
58 269

Specimen: Silver-plated copper wire, Teflon insulation

No. of Specimens: 40

Wire Gauge: 22 AWG. Number of Strands: 19

Strip Gap: 1/8 inch

Soldering Method: (X) Pot ( ) Soldering Iron

Solder Used: Alpha Metals 60/40

Flux Used: Alpha Metals #348 - 25 liquid

Cleaning Method (Before Soldering): brushing in 1,1,1 - trichloroethane

Soldering Temperature: 450°F

Immersion Time: 5,20,40,80 Seconds Immersion Depth: 1/8 Inch

Heat Sink Used: ( ) Yes (X) No

Fatigue Tests:

A 21:	44	39	21	20	14	11	11	11	11	8	$\bar{x} = 19.0$	$\sigma = 12.6$
A 22:	14	13	11	10	10	9	9	9	9	9	$\bar{x} = 10.3$	$\sigma = 1.8$
A 23:	13	12	9	8	8	8	8	7	7	7	$\bar{x} = 8.7$	$\sigma = 2.1$
A 24:	26	21	15	15	9	8	7	7	7	7	$\bar{x} = 12$	$\sigma = 6.8$

Remarks:

Wicking depth: A 21: 0.335 inch  
A 22: 0.490 inch  
A 23: 0.875 inch  
A 24: 0.550 inch

TEST DATA SHEET  
 Integrity of Electrical Connections  
 Contract NAS 8-11475

Test Series Number:

Lab. Report Number:

A 25, A 26

58 457

Specimen: Nickel-plated copper, Teflon insulation

No. of Specimens: 24

Wire Gauge: 24                      AWG.                      Number of Strands: 7

Strip Gap: 1/10 inch

Soldering Method:                      ( X ) Pot                      (   ) Soldering Iron

Solder Used: Alpha Metals 60/40

Flux Used: Alpha Metals # 346 - 25 liquid

Cleaning Method (Before Soldering):

Soldering Temperature:                      450°F

Immersion Time: 20, 80                      Seconds                      Immersion Depth: 1/10                      Inch

Heat Sink Used:                      (   ) Yes                      ( X ) No

Fatigue Tests:

A 25:	25	17	14	13	13	11	11	8	8	5	$\bar{x} = 12.5$	$\sigma = 5.6$
-------	----	----	----	----	----	----	----	---	---	---	------------------	----------------

A 26:	12	10	9	9	9	9	8	8	8	7	$\bar{x} = 9$	$\sigma = 1.0$
-------	----	----	---	---	---	---	---	---	---	---	---------------	----------------

Remarks:

Wicking depth:                      A 25:                      0.205 inch

A 26:                      0.515 inch

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

A27, A28,

Lab. Report Number:

58 457

Specimen: Nickel-plated copper wire, Teflon insulation

No. of Specimens: 24

Wire Gauge: 24                      AWG.                      Number of Strands: 7

Strip Gap: 1/10 inch

Soldering Method:                      (X ) Pot                      (   ) Soldering Iron

Solder Used: Alpha Metals 60/40

Flux Used: Alpha Metals # 346-25 liquid

Cleaning Method (Before Soldering): brushing in 1,1,1 - trichloroethane

Soldering Temperature: 550°F.

Immersion Time: 20,80                      Seconds                      Immersion Depth: 1/10      Inch

Heat Sink Used:                      (   ) Yes                      (X ) No

Fatigue Tests:

A27: 12 12 11 10 10 9 9 9 8 7                       $\bar{X} = 9.7$   $\sigma = 1.2$

A28: 14 12 11 11 10 10 8 8 7 7                       $\bar{X} = 9.4$   $\sigma = 1.5$

Remarks:

Wicking Depth:                      A27: 0.480 inch

A28: 0.675 inch

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

A 29

Lab. Report Number:

58 595

Specimen: Nickel-plated copper wire, Teflon insulation  
Connector pin #202

No. of Specimens: 12

Wire Gauge: 22

Awg.

Number of Strands: 19

Strip Gap: 1/8 inch

Soldering Method:

( ) Pot

( X ) Soldering Iron

Solder Used:

Flux Used:

} Alpha Metals 60/40 with N.R.G. Flux Core

Cleaning Method (Before Soldering): Wires brushed in 1,1,1 - trichloroethane  
cup terminals vapor degreased in TMC Freon

Soldering Temperature:

Immersion Time: 0

Seconds

Immersion Depth :

0 Inch

Heat Sink Used:

( X ) Yes

( ) No

Fatigue Tests:

23 21 20 20 19 19 17 17 16 15

$\bar{x} = 18.7$

$\sigma = 2.4$

Remarks:

Wicking depth:

None

Photomicrograph No.:

24 592

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

A 30

Lab. Report Number:

58 595

Specimen: Nickel-plated copper wire, Teflon insulation  
Connector pin #202

No. of Specimens: 12

Wire Gauge: 22 Awg. Number of Strands: 19

Strip Gap: 1/8 inch

Soldering Method: ( ) Pot (X) Soldering Iron

Solder Used: } Alpha Metals 60/40 with N.R.G. Flux Core  
Flux Used: }Cleaning Method (Before Soldering): Wires brushed in 1,1,1 - trichloroethane  
cup terminals vapor degreased in TMC Freon

Soldering Temperature:

Immersion Time: 0 Seconds Immersion Depth: 0 Inch

Heat Sink Used: ( ) Yes (X) No

Fatigue Tests:

39 37 36 32 25 24 23 18 17 10

 $\bar{x} = 26.1$  $s = 9.7$ 

Remarks:

Wicking depth: 0.140 inch

Photomicrograph: 24 593

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

Lab. Report Number:

A 31

58 595

Specimen: 12

No. of Specimens: Nickel-plated copper wire, Teflon insulation  
Connector pin #202

Wire Gauge: 24      Avg.      Number of Strands: 7

Strip Gap: 1/8 inch

Soldering Method:      ( ) Pot      (X) Soldering Iron

Solder Used: }  
Flux Used: } Alpha Metals 60/40 with N.R.G. Flux CoreCleaning Method (Before Soldering): Wires brushed in 1,1,1 - trichloroethane  
cup terminals vapor degreased in TMC Freon

Soldering Temperature:

Immersion Time: 0      Seconds      Immersion Depth: 0      Inch

Heat Sink Used:      (X) Yes      ( ) No

Fatigue Tests:

17 16 13 12 11 11 11 10 9 8

 $\bar{x} = 11.8$  $\sigma = 2.9$ 

Remarks:

Wicking depth: None

Photomicrograph No.: 24 594

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number:

A 32

Lab. Report Number:

58 595

Specimen: Nickel-plated copper wire, Teflon insulation

Connector pin #202

No. of Specimens: 10

Wire Gauge: 24 Awg. Number of Strands: 7

Strip Gap: 1/8 inch

Soldering Method: ( ) Pot (X) Soldering Iron

Solder Used: }  
Flux Used: } Alpha Metals 60/40 with N.R.G. Flux CoreCleaning Method (Before Soldering): Wires brushed in 1,1,1 - trichloroethane  
Soldering Temperature: cup terminals vapor degreased in TMC Freon

Immersion Time: 0 Seconds Immersion Depth: 0 Inch

Heat Sink Used: ( ) Yes (X) No

Fatigue Tests:

22 21 20 16 13 12 12 9

 $\bar{x} = 15.6$  $\sigma = 4.9$ 

Remarks:

Wicking Depth: 0.630 inch

Photomicrograph No.: 24 595

Paragraph 9.5

Test Data Sheets for Subtask (g)

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-1

Lab. Report Number: 56 192-1

Specimen: • 22 AWG. 19 strand copper wire, silver-plated, teflon insulation  
• No. 202 connector pins, goldplated

Number of Specimens: 60

Solder Used: } Alpha Metals 60/40 with plastic core (non-activated)  
Flux Used: }

Cleaning Method (before soldering):

Wires: None

Pins: 2 Min. Vapor degreased in Trichloroethylene

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
*	25 Specimens				*	25 Specimens			
13.5	21.8	21.8	22.0	22.0	6.4	22.0	21.7	21.7	21.7
15.3	22.1	22.1	22.1	22.0	11.8	21.6	22.0	22.1	22.1
19.3	22.0	21.9	22.0	22.1	16.4	22.0	22.0	22.0	22.0
21.1	21.9	22.0	21.9	22.1	8.0	21.7	21.6	21.6	
	21.9	22.0	22.0	21.8	12.8	22.1	22.1	22.0	
	22.0				20.4				
	Avg. Value:	21.97	1	lbs	18.5	Avg. Value:	21.88	lbs	
	Std. Dev.:	0.092		lbs		Std. Dev.:	1.97	lbs	
	*Avg.:	17.3		lbs		*Avg.:	13.47	lbs	
	Std.Dev.:	3.31		lbs		Std.Dev:	5.26	lbs	

Fatigue Tests: Through 110° under 3/4 lb. tension

51 42 63 49 42 cycles; Avg. 49.4 cycles

Remarks: Photomicrographs No. 22 848, 22 920, 22 935

\* Broke in solder joint

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-2

Lab. Report Number: 56192-2

Specimen:     • 24 AWG. 7 strand copper wire, silver-plated, teflon insulation  
                  • No. 202 connector pin, goldplated

Number of Specimens: 60

Solder Used:     }  
 Flux Used:       } Alpha Metals 60/40 with N.R.G. core (activated)

Cleaning Method (before soldering):

Wires: }  
 Pins:   } 2 min. Vapor degreased in Trichloroethylene

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
12.6	12.6	12.6	12.6	12.5	12.6	12.8	12.6	12.8	12.7
12.7	12.7	12.7	12.7	12.8	12.5	12.7	12.6	12.7	12.5
12.8	12.8	12.8	12.8	12.7	12.6	12.6	12.7	12.6	12.6
12.8	12.7	12.7	12.7	12.7	12.7	12.7	12.6	12.5	12.6
12.8	12.7	12.7	12.7	12.7	12.6	12.7	12.7	12.7	12.6
Avg. Value: 12.7 lbs					Avg. Value: 12.64 lbs				
Std. Dev.: 0.079 lbs					Std. Dev.: 0.091 lbs				

Fatigue Tests: Through 110° under 3/4 lb. tension

8 20 14 7 19 cycles; avg. 14 cycles

Remarks: Photomicrographs No. 22 849, 22 922, 22 936

TEST DATA SHEET  
Integrity of Electrical Connections  
Contract NAS 8-11475

Test Series Number: G-3

Lab. Report Number: 56192-3

Specimen: • 28 AWG. 7 strand copper wire, solder coated, vinyl insulation  
• No. 202 connector pin, goldplated

Number of Specimens: 60

Solder Used: }  
Flux Used: } Alpha Metals 60/40 with N.R.G. Core (Activated)

Cleaning Method (before soldering):

Wires: }  
Pins: } 2 min. Vapor degreased in Trichloroethylene

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
6.1	6.1	6.1	6.0	6.0	5.9	6.1	6.1	6.1	6.1
6.0	6.1	6.0	6.1	2.2	6.0	6.0	6.0	6.0	6.1
6.1	6.0	6.0	6.0	6.0	6.1	5.8	6.0	6.0	6.0
6.1	6.0	6.0	6.1	6.0	6.1	6.1	5.9	6.0	6.1
6.0	6.0	6.1	6.1	6.0	5.8	5.9	5.9	6.1	6.1
Avg. Value: 5.88 lbs					Avg. Value: 6.01 lbs				
Std. Dev.: 0.77 lbs					Std. Dev.: 0.098 lbs				

Fatigue Tests: Through 110° under 3/4 lb. tension

9 5 4 8 5 cycles; Avg. 6.2 cycles

Remarks: Photomicrographs No. 22 850, 22 921, 22 937

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-4

Lab. Report Number: 56 192-4

Specimen: • 24 AWG. 7 strand copper wire, solder coated, vinyl insulation  
 • Turret terminal LS-8958-2, goldplated

Number of Specimens: 65

Solder Used: } Alpha Metals 60/40 with N.R.G. Core (Activated)  
 Flux Used: }

Cleaning Method (before soldering):

Wire: } 2 Min. Vapor degreasing in Trichloroethylene  
 Pins: }

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
9.7	10.3	6.8	8.4	10.8	10.1	10.2	7.7	8.6	7.8
9.1	10.0	7.4	10.6	8.6	9.7	8.5	7.9	7.3	11.1
9.2	6.7	8.4	6.8	6.6	9.5	5.8	10.6	11.2	10.2
8.6	9.4	10.0	6.2	10.2	10.0	9.5	8.5	8.7	8.2
8.4	7.5	6.8	8.7	6.0	11.1	9.9	8.3	8.8	6.4
Avg. Value: 8.45 lbs					Avg. Value: 9.02 lbs				
Std. Dev.: 1.48 lbs					Std. Dev.: 1.43 lbs				

Fatigue Tests: Through 110° under 3/4 lb. tension

Outer joint: 18 20 35 17 20 cycles; Avg. 22 cycles

Inner joint: 18 18 27 17 15 cycles; Ave. 19 cycles

Remarks: Photomicrographs No. 22 854, 22 918, 22 940, 22 941

TEST DATA SHEET  
Integrity of Electrical Connections  
Contract NAS 8-11475

Test Series Number: G-5

Lab. Report Number: 56 192-5

Specimen: • 18 AWG. 19 strand copper wire, solder coated, vinyl insulation  
• No. 162 connector pin, goldplated

Number of Specimens: 60

Solder Used: }

Flux Used: }

Alpha Metals 60/40 with Plastic Core (non-activated)

Cleaning Method (before soldering):

Wire: }

Pins: }

2 Min. Vapor degreasing in Trichloroethylene

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
46.2	53.9	22.2	34.2	47.9	56.8	55.0	56.2	41.4	56.3
55.8	47.1	56.9	35.0	53.2	51.8	49.3	57.5	47.4	38.9
53.0	42.8	51.5	57.2	57.0	58.0	56.8	37.1	39.1	56.2
57.2	57.1	57.2	57.2	56.5	56.3	58.0	46.0	50.1	56.7
45.0	56.7	51.4	55.6	54.2	50.2	50.0	54.8	55.0	47.2
Avg. Value:		50.48	lbs		Avg. Value:		51.29	lbs	
Std. Dev.:		8.92	lbs		Std. Dev.:		6.53	lbs	

Fatigue Tests:

Through 110° under 1 lb. load

102 71 165 93 93 cycles; avg. 105 cycles

Remarks: Photomicrographs No. 22 851, 22 923, 22 938

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-6

Lab. Report Number: 56 192-6

Specimen: • 28 AWG. 7 strand copper wire, silver-plated, teflon insulation  
• Turret Terminal LS-8958-2, goldplated

Number of Specimens: 65

Solder Used: }  
Flux Used: } Alpha Metals 60/40 with Plastic Core (non-activated)

Cleaning Method (before soldering):

Wire: }  
Turrets: } Vapor degreased in trichloroethylene

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
4.18	4.47	4.38	4.00	4.69	4.71	3.83	4.34	3.10	4.65
4.70	4.71	3.78	4.52	4.71	3.82	4.00	3.72	3.94	3.82
3.96	4.71	4.36	3.84	3.67	4.33	4.58	4.48	4.09	4.60
4.18	4.72	4.10	4.29	3.78	4.48	2.70	4.37	4.56	3.49
4.04	4.72	4.69	4.72	3.97	4.51	3.12	4.31	3.90	3.87
Avg. Value: 4.31 lbs					Avg. Value: 4.05 lbs				
Std. Dev.: 0.39 lbs					Std. Dev.: 0.49 lbs				

Fatigue Tests: Through 110° under 1 lb. load

Outer joint: 7 3 3 6 5 cycles; avg. 4.8 cycles.

Inner joint: 6 4 7 8 3 cycles; avg. 5.6 cycles

Remarks: Photomicrographs No. 22 853, 22 919, 22 942, 22 943

TEST DATA SHEET  
Integrity of Electrical Connections  
Contract NAS 8-11475

Test Series Number: G-7

Lab. Report Number: 56 192-7

Specimen:     • 18 AWG. 19 strand copper wire, silver-plated, Teflon insulation  
              • No. 162 connector pin, goldplated

Number of Specimens: 60

Solder Used:     } Alpha Metals 60/40 with N.R.G. core (activated)  
Flux Used:        }

Cleaning Method (before soldering):

Wires:     }  
Pins:       } Vapor degreased in Trichloroethylene

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
55.9	56.0	56.0	55.8	55.1	55.8	56.3	56.2	56.1	55.7
56.0	56.2	56.2	56.5	56.2	55.4	56.3	56.0	56.0	56.0
56.4	56.5	56.4	56.4	56.4	55.7	56.2	56.0	56.0	56.0
56.1	56.0	56.0	56.2	56.2	56.2	56.2	56.2	54.8	56.0
56.0	56.3	56.3	56.3	56.3	55.5	56.2	56.1	56.0	56.2
Avg. Value: 56.15 lbs					Avg. Value: 55.95 lbs				
Std. Dev.: 0.28 lbs					Std. Dev.: 0.34 lbs				

Fatigue Tests: Through 110° under 1 lb. load

65 61 71 59 45 cycles; Avg. 60.2 cycles

Remarks: Photomicrographs No. 22 852, 22 924, 22 939

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-8

Lab. Report Number: 58 573

● 24 AWG. 7 strand copper wire, nickel-plated, Teflon insulation  
Specimen: ● No. 202 connector pins, goldplated

Number of Specimens: 5

Solder Used: }  
Flux Used: } Alpha Metals 60/40 with Plastic Core (non-activated)

Cleaning Method (before soldering):

Wire: }  
Pins: } Vapor degreased in Trichloroethylene

Test Results (breaking strength in pounds):

Not Exposed to Corrosion

Specimens

Exposed to Corrosion

Specimens

Wire would not tin with the plastic core solder (non-activated flux). Solder  
balled and fell off. Five cups were filled with solder and wire inserted.

Avg. Value: -- lbs  
Std. Dev.: -- lbs

Avg. Value: -- lbs  
Std. Dev.: -- lbs

Fatigue Tests:

Remarks: Photomicrographs No. 24 735, 24 802, 24 807

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-9

Lab. Report Number: 58573

Specimen: • 24 AWG. 7 strand copper wire, nickel plated, Teflon insulation  
 • No. 202 connector pins, goldplated

Number of Specimens: 60

Solder Used:

Flux Used:

} Alpha Metals 60/40 with N.R.G. Core (Activated)

Cleaning Method (before soldering):

Wires: } Vapor degreased in Trichloroethylene, followed by TMC Freon Rinse  
 Pins: }  
 Test Results (breaking strength in pounds):

## Not Exposed to Corrosion

25 Specimens

15.1	15.2	15.2	15.2	15.1
15.2	15.2	15.1	15.2	15.2
13.2	15.2	15.2	15.2	15.2
15.2	15.2	15.2	15.1	15.1
15.2	15.1	15.1	15.2	15.2

Avg. Value: 15.17 lbs  
 Std. Dev.: 0.405 lbs

## Exposed to Corrosion

25 Specimens

15.1	15.0	15.2	15.1	15.0
15.1	15.1	15.2	15.1	15.1
15.0	15.0	15.1	14.9	15.0
15.0	15.2	15.1	15.2	15.0
15.2	15.0	15.1	15.1	15.0

Avg. Value: 15.08 lbs  
 Std. Dev.: 0.084 lbs

Fatigue Tests: Through 110° under 1 lb. load

15 9 10 9 10; Avg. 10.6 cycles

Remarks: Photomicrographs No. 24 736, 24803, 24 808

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-10

Lab. Report Number: 58 573

- 28 AWG. 7 strand copper wire, nickel-plated, Teflon insulation

Specimen: • Turret Terminal IS-8958-2, solder-plated

Number of Specimens: 65

Solder Used: }  
Flux Used: } Alpha Metals 60/40 with N.R.G.Core (Activated)

Cleaning Method (before soldering):

Wires: }  
Turrets: } Vapor degreased in Trichloroethylene, followed by Rinse in Chloroethane

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
3.9	4.7	5.2	3.5	3.6	3.6	3.7	3.2	4.1	5.3
3.4	4.7	3.9	5.4	4.8	5.1	4.4	3.0	4.0	4.6
4.5	4.2	4.3	5.4	3.5	4.0	3.2	5.2	4.3	4.5
4.7	5.2	4.9	5.1	3.1	5.3	5.0	4.1	4.3	3.4
5.0	3.2	4.8	4.6	5.0	5.0	3.1	3.6	4.5	3.1
Avg. Value:		4.42	lbs		Avg. Value:		4.14	lbs	
Std. Dev.:		0.716	lbs		Std. Dev.:		0.747	lbs	

Fatigue Tests: Through 110° under 1 lb. load

Outer joint: 8 6 3 6 6 ; Avg. 5.8 cycles

Inner joint: 7 11 6 5 6 ; Avg. 7 cycles

Remarks: Photomicrographs No. 24 737, 24 805, 24 806

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-11

Lab. Report Number: 58 573

Specimen: • 22 AWG. 19 strand copper wire, nickel-plated, Teflon insulation  
 • No. 202 connector pins, goldplated

Number of Specimens: 60

Solder Used: }  
 Flux Used: } Alpha Metals 60/40 with N.R.G. Core (Activated)

Cleaning Method (before soldering):

Wires: }  
 Pins: } Vapor degreased in Trichloroethylene followed by Rinse in  
 chlorothane

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
25.0	25.0	25.1	23.3	25.0	25.2	24.5	25.1	25.0	24.6
24.8	25.1	25.2	25.1	25.0	24.5	24.9	25.0	24.9	24.9
25.0	25.1	25.1	24.9	25.0	25.0	24.8	24.9	25.0	24.4
23.3	25.0	24.5	22.5	25.1	24.6	25.0	24.5	25.0	24.9
25.0	25.1	25.0	25.0	25.0	24.6	23.7	25.2	25.1	24.9
Avg. Value: 24.77 lbs					Avg. Value: 24.81 lbs				
Std. Dev.: 0.680 lbs					Std. Dev.: 0.327 lbs				

Fatigue Tests: Through 110° under 1 lb. load

24 18 23 15 20 cycles; Avg. 20 cycles.

Remarks: Photomicrographs No. 24 738, 24 804, 24 809

TEST DATA SHEET  
 Integrity of Electrical Connections  
 Contract NAS 8-11475

Test Series Number: G-12

Lab. Report Number: 58751

● 28 AWG. 7 strand copper wire, silver-plated, vinyl insulation  
 Specimen: ● No. 202 connector pins, goldplated

Number of Specimens: 60

Solder Used: }  
 Flux Used: } Alpha Metals 60/40 with N.R.G. Core (Activated)

Cleaning Method (before soldering):

Wires: in chlorothane with bristle brush

Pins: vapor degreased in TMC Freon

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
5.5	5.3	5.6	5.6	5.7	5.1	5.9	5.6	3.3	4.0
5.3	5.7	5.9	5.9	3.5	6.2	3.4	3.7	4.1	6.1
5.7	6.1	5.4	6.0	5.3	6.0	6.1	6.1	4.7	5.8
5.4	3.2	5.8	6.0	5.6	5.6	4.5	4.0	5.9	6.1
5.7	5.0	5.6	5.5	5.8	5.8	5.9	6.1	5.9	6.0
Avg. Value: 5.4 lbs					Avg. Value: 5.3 lbs				
Std. Dev.: 0.683 lbs					Std. Dev.: 0.982 lbs				

Fatigue Tests: Through 110° under 1 lb. load

5 5 3 3 3 cycles; Avg. 3.8 cycles.

Remarks: Photomicrographs No. 24 534, 24 535, 24 601, 24 602, 24 603, 24 616

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-13

Lab. Report Number: 58 885

Specimen: • 28 AWG. 7 strand copper wire, silver-plated, vinyl insulation  
• Turret terminal LS-8958-2, solder-plated

Number of Specimens: 65

Solder Used: } Alpha Metals 60/40 with N.R.G. Core (Activated)  
Flux Used: }

Cleaning Method (before soldering):

Wires: in chlorothane with bristle brush

Turrets: Vapor degreased in TMC Freon

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
5.9	6.7	4.9	6.3	5.2	5.8	6.0	5.3	5.6	5.9
4.9	6.4	5.2	3.8	5.3	5.8	4.9	5.5	5.8	3.6
5.9	5.7	5.9	4.4	4.5	5.9	2.8	5.6	5.8	5.8
6.0	5.7	5.3	5.5	5.6	5.6	5.2	5.2	6.1	6.2
3.6	5.2	3.7	3.5	4.9	4.6	5.4	5.7	5.9	5.2
Avg. Value: 5.2 lbs					Avg. Value: 5.4 lbs				
Std. Dev.: 0.886 lbs					Std. Dev.: 0.771 lbs				

Fatigue Tests: Through 110° under 1 lb load

Outer: 6 5 3 3 3 cycles

Inner: 6 7 6 6 3 cycles

Remarks: Photomicrographs No. 24 789, 24 793, 24 794, 24 795, 24 796

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-14

Lab. Report Number: 58 958

Specimen:      • 22 AWG. 19 strand copper wire, silver-plated, vinyl insulation  
                  • No. 202 connector pin, goldplated

Number of Specimens: 60

Solder Used: }  
 Flux Used:    } Alpha Metals 60/40 with Plastic Core (non-activated)

Cleaning Method (before soldering):

Wires in chlorothane with bristle brush

Connector pins vapor-degreased in TMC Freon

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
23.0	23.1	22.9	22.9	23.1	22.4	22.3	22.1	22.5	22.4
22.9	23.0	23.0	23.0	22.5	22.2	22.2	22.2	22.5	22.3
23.0	23.1	23.0	22.9	23.1	22.3	22.5	22.4	22.5	22.2
22.6	22.8	22.9	23.0	23.0	22.3	22.2	21.6	17.6	22.2
22.9	23.0	22.9	23.0	23.0	22.0	22.4	22.2	22.4	22.4
Avg. Value: 22.94    lbs					Avg. Value: 22.10    lbs				
Std. Dev.:    0.142    lbs					Std. Dev.:    0.93    lbs				

Fatigue Tests: Through 110° degrees under 1 lb. load

47 28 39 41 34 cycles

Remarks: Photomicrographs No. 24 790, 24 797, 24 798, 24 799, 24 800

TEST DATA SHEET

## Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-15

Lab. Report Number: 59 024

Specimen: • 18 AWG. 19 strand copper wire, silver-plated, vinyl insulation  
 • No. 162 connector pin, goldplated

Number of Specimens: 60

Solder Used: }  
 Flux Used: } Alpha Metals 60/40 with Plastic Core (non-activated)

Cleaning Method (before soldering):

Wires in chlorothane with bristle brush

Connector pins vapor degreased in TMC Freon

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
26 Specimens					25 Specimens				
56.4	56.2	56.4	56.7	56.6	55.8	56.0	56.0	55.8	55.4
56.7	56.4	56.1	56.6	58.0	56.0	56.2	56.0	56.1	56.1
56.6	56.0	56.8	56.9	56.0	56.0	55.5	56.0	55.9	56.2
56.8	56.6	56.8	56.6	56.3	55.7	55.8	56.1	55.9	55.6
56.8	56.5	56.6	56.6	56.6	56.1	55.9	55.8	55.5	55.9
56.6									
Avg. Value: 56.58 lbs					Avg. Value: 55.89 lbs				
Std. Dev.: 0.378 lbs					Std. Dev.: 0.218 lbs				

Fatigue Tests: Through 110° degrees under 1 lb. load

109 91 57 51 50 cycles

Remarks: Photomicrographs No. 24 840, 24 954, 24 955

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-16

Lab. Report Number: 59134

Specimen: • 24 AWG. 7 strand copper wire, nickel-plated, vinyl insulation  
• No. 202 connector pin, goldplated

Number of Specimens: 60

Solder Used: } Alpha Metals 60/40 with N.R.G. Core (Activated)  
Flux Used: }

Cleaning Method (before soldering):  
Wires in chlorothane with bristle brush

Connector pins vapor degreased in TMC Freon

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
25 Specimens					25 Specimens				
14.6	14.7	14.8	14.7	14.5	14.9	14.9	14.9	14.8	14.6
14.8	14.8	14.7	14.6	14.6	14.8	14.9	14.5	14.9	15.0
14.6	14.7	14.6	14.7	14.8	14.9	14.9	14.8	14.9	15.0
14.7	14.9	14.7	14.7	14.8	14.9	14.8	14.7	14.8	14.6
14.8	14.8	14.9	14.6	14.7	14.9	14.7	14.9	14.8	14.9
Avg. Value: 14.65 lbs					Avg. Value: 14.83 lbs				
Std. Dev.: 0.116 lbs					Std. Dev.: 0.134 lbs				

Fatigue Tests: Through 110° under 1 lb. load

27 11 11 10 9 cycles

Remarks: Photomicrographs No. 24 841, 24 956, 24 957

TEST DATA SHEET

Integrity of Electrical Connections

Contract NAS 8-11475

Test Series Number: G-17

Lab. Report Number: 59 186

Specimen: • 28 AWG. 7 strand copper wire, nickel-plated, vinyl insulation  
• No. 202 connector pin, goldplated

Number of Specimens: 50

Solder Used: } Fairmount 60/40 with H-32 Core (Hydrazine containing, strongly  
Flux Used: } activated.

Cleaning Method (before soldering):

Wires in chlorothane with bristle brush

Connector pins vapor degreased in TMC Freon

Test Results (breaking strength in pounds):

Not Exposed to Corrosion					Exposed to Corrosion				
18 Specimens					18 Specimens				
5.7	5.6	5.7	5.7	5.6	5.8	5.7	5.8	5.7	5.8
5.7	5.5	5.7	5.5	5.7	5.8	5.8	5.8	5.8	5.6
5.7	5.7	5.7	5.7		5.6	5.7	5.7	5.7	
5.7	5.6	5.7	5.7		5.8	5.7	5.8	5.7	

Avg. Value: 5.66 lbs  
Std. Dev.: 0.057 lbs

Avg. Value: 5.74 lbs  
Std. Dev.: 0.070 lbs

Fatigue Tests: Through 110° under 1 lb. load  
7 6 5 5 5 cycles

Remarks: Photomicrographs No. 24 842, 24 952, 24 953